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THE ENGINE ROOM OF A GREAT STEAMER.

It is practically impossible, says the Engineer, London, to convey an accurate impression of the appearance of the engine room of a great modern steamer by photographs. There is not sufficient light available, and what there is is uncertain and unsuitable for the photographer's purposes. Again, it is seldom possible to secure a sufficient distance between the camera and the portion of the machinery to be photographed. Nothing remains then but for an artist to make sketches, and to do this makes no small demand on the artist's skill and experience. We venture to think that our reproductions of drawings, made in the engine room of the Peninsular and Oriental Company's new and splendid steamship Caledonia, will convince our readers that, difficult as the task is, it is not impossible.

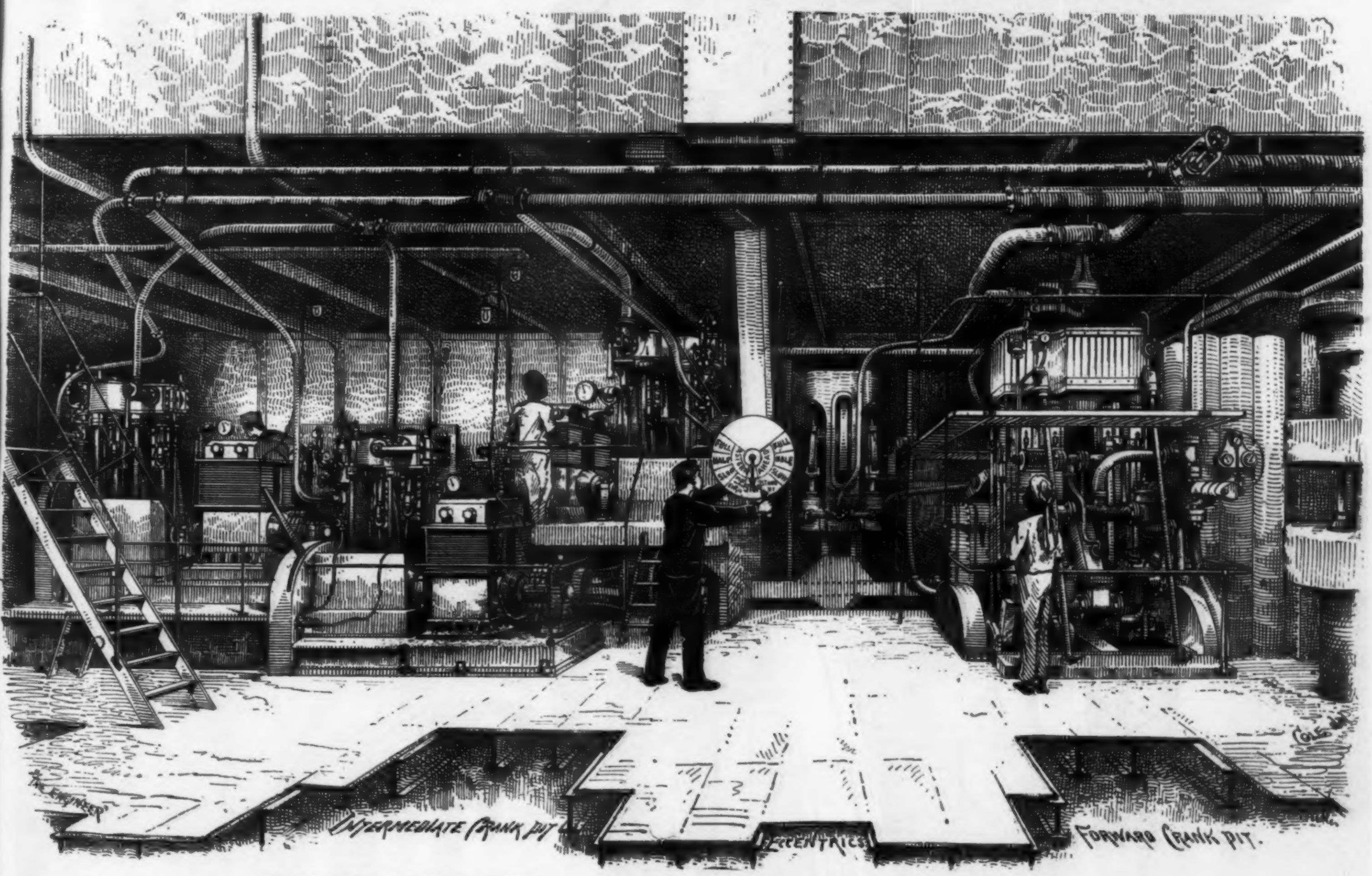
These drawings are seven in number. The third shows the lower platform as seen from the port side of the ship, with Messrs. Brown Bros.' reversing gear. by iron bands; these are painted black, the canvas and netting light stone color. Under the grating, in the extreme left hand corner, may be noticed one of the exhaust pipes from the low pressure cylinder to the condenser. Higher up in the picture, but still to the extreme left, is seen the steering engine. The inverted dome at the top is a portion of the Weir feed water heater.

The fifth view was taken on the top platform looking astern. In front is seen the piston valve casing of one of the high pressure cylinders, the high pressure cylinder and the lifting gear for the intermediate cylinder cover attached to the transverse girder, in which position it remains while the ship is at sea. In the left hand front corner is the upper portion of the Weir heater. The main steam stop valve can be seen at the off side of the high pressure valve casing.

The first view affords an excellent example of the difficulties to which we have referred as standing in the way of an artist. Here it has been found necessary to suppose the main engines to be removed alto- where they are inclosed in iron pipes; the iron structure of the ship is used for the return circuit. Joints in the wires are avoided by the use of special junction boxes, each serving for ten lights. The Caledonia is the forty-fourth Peninsular and Oriental vessel fitted by the same contractors, who, besides, have eight others just completed or in hand.

The seventh view, on the starboard side of the engine room, illustrates the two circulating pumps set at an angle. A portion of the condenser has been broken away in order that the Kingston valve may be seen. Just ahead of the forward centrifugal is a duplex pump. At the top left hand corner is a portion of the Weir heater.

The Caledonia is a ship of 7,500 tons and 11,000 indicated horse power, constructed and engined by Messrs. Caird & Company, Greenock. She is 486 ft. long, 54 ft. beam and 37 ft. deep. She has accommodation for 320 saloon passengers and 150 second cabin passengers, but no steerage accommodation whatever, none being provided in the Peninsular and Oriental Company's



STEAMER CALEDONIA—THE ELECTRIC LIGHT INSTALLATION.

The Caledonia is a single screw ship. Looking through the space between the A frames, the condenser is seen. On the extreme left is the bulkhead between the engine and boiler rooms. Against the bulkhead stands a Weir's feed pump. The small "wheel" on the A frame is the cylindrical casing of a Durham and Churchill marine governor. Immediately under it is the engine room log slate. The clock, counter and desk on the other frame speak for themselves. The grating at the top is the second platform at the level of the links.

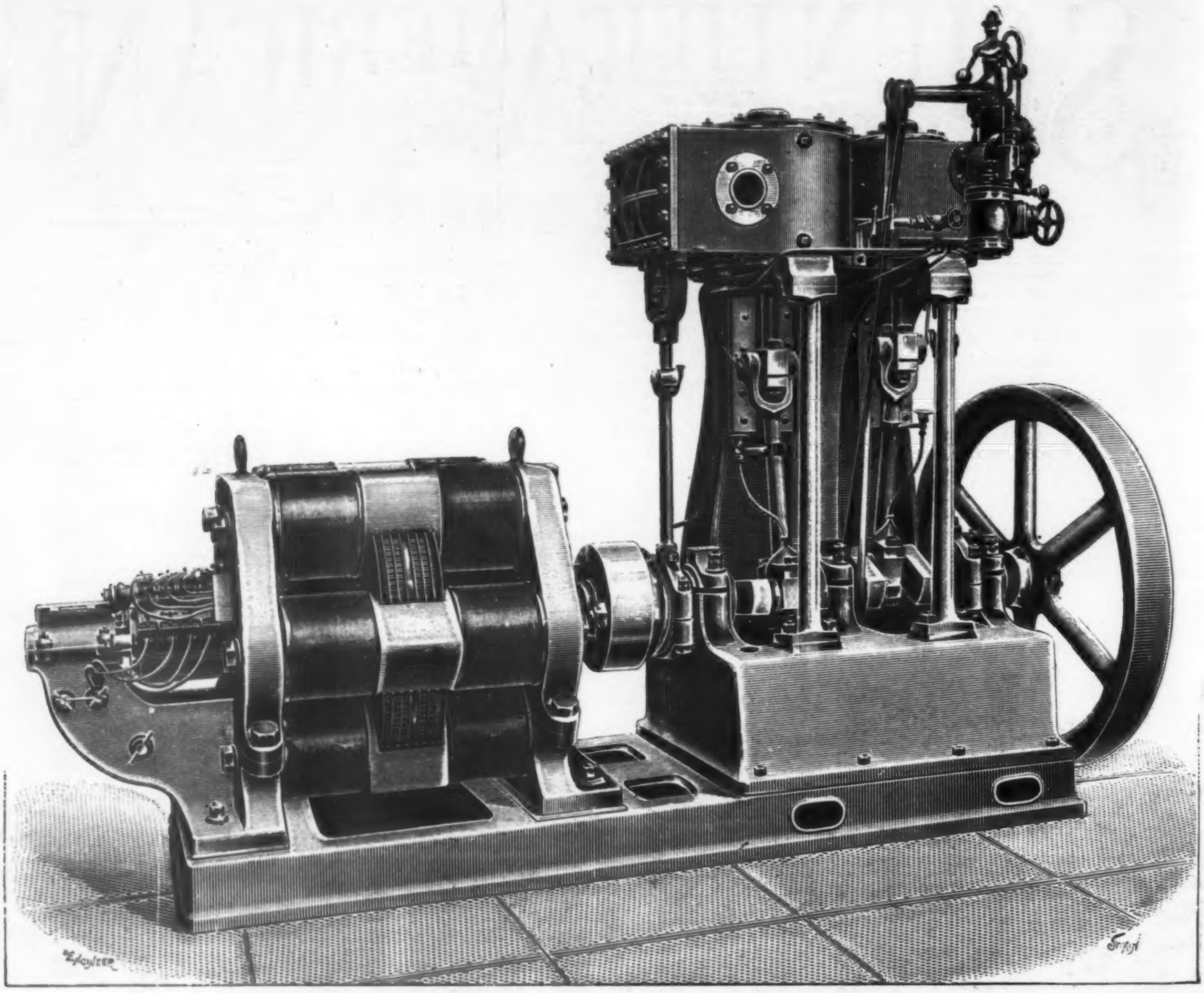
The third drawing conveys an excellent idea of the great size of the crank shaft and connecting rods. The crank guards are supposed to be unshipped, and we are looking astern through the A frame.

The sixth view is taken on the third platform. At each end we see one of the two high pressure cylinders. To the right of the center is the top of the valve casing for the intermediate cylinder, and at the other end can be seen the rocking lever by which the high pressure valve spindle is driven. The pipes seen in the background are the main steam pipes; those in the foreground are the exhaust pipes to the intermediate cylinder. The pipes are all very heavily clothed with non-conducting composition, which greatly adds to their apparent diameter. The composition is covered with canvas and that again with wire netting secured gether, in order that the electric light engines and dynamos may be seen without obstruction. At the extreme left is seen the spare crank shaft up-ended against the bulkhead. Close to it is the hydraulic engine, supplying water under pressure for working derricks, etc. Right in front is a donkey pump

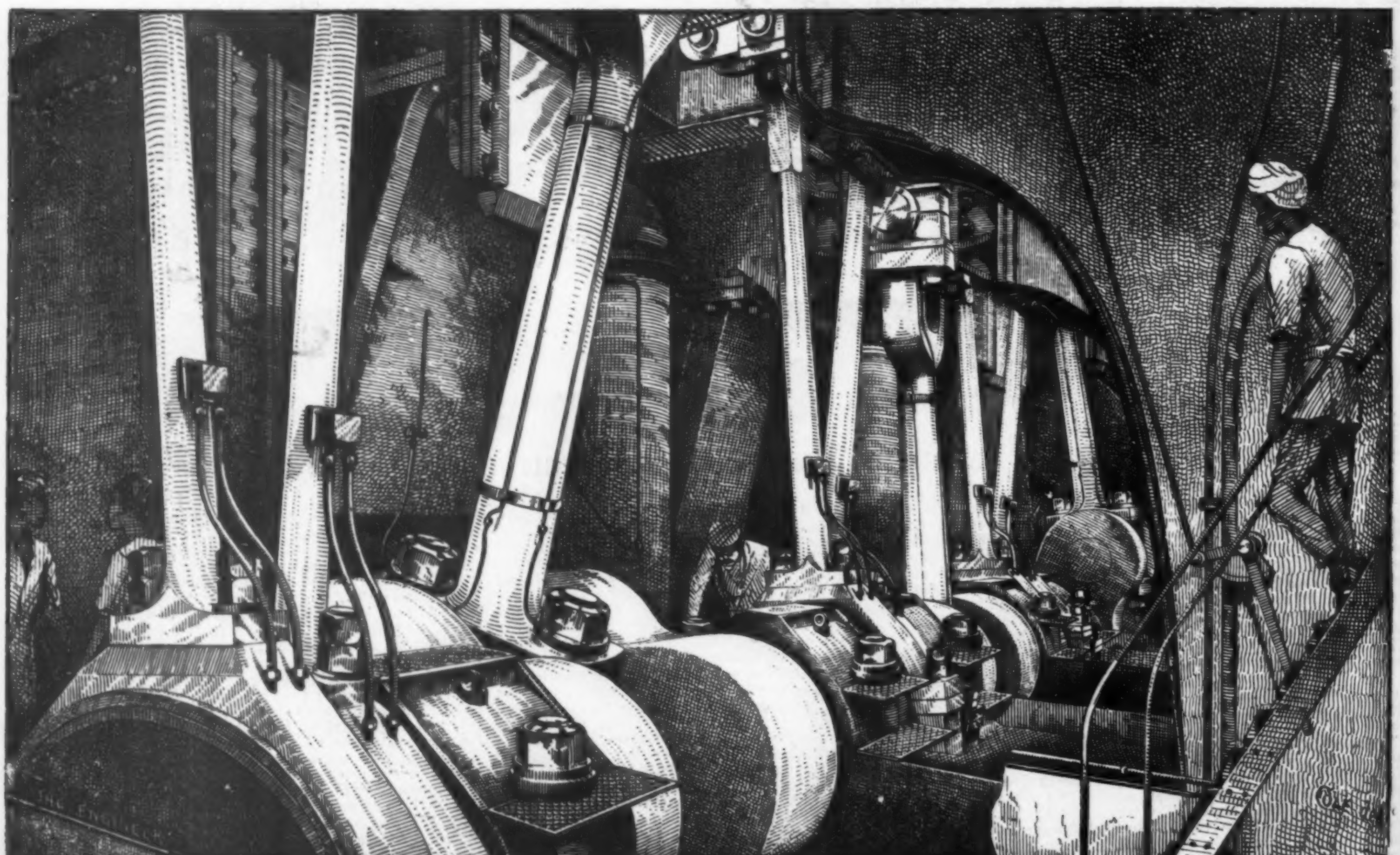
The electric lighting on board this ship has been carried out by Messrs. Siemens Bros. & Company. There are 734 incandescent lamps of 16 candle power fitted up in the vessel, besides eight deck lanterns with three lamps each for use when discharging cargo, and two arc lamps for use in passing through the Suez Canal, one of 50 amperes in a projector for use at the bows and the other of 20 amperes for a mast head light. These lamps if all running at once would require 52 kilowatts, and this is provided for by three sets of generating plants, each of 23 kilowatts; usually one set is held in reserve. The three sets are quite similar and each consist of a Siemens H. B. $\frac{14}{10}$ dynamo for 220 amperes at 105 volts, coupled direct to a Tangye Archer type vertical compound engine, with 8 in. and 16 in. cylinders and 10 in. stroke, running at 220 revolutions per minute and working with 150 lb. steam pressure. We illustrate an engine and dynamo. Both slide valves are Trick ported. The wiring is carried out with highly insulated India rubber covered wires in teak casings, except in the engine and boiler rooms, steamships, simply because there is no demand for it. She has space for 1,500 tons of cargo. She is commanded by Capt. Andrews and Mr. J. Stevenson is chief engineer. Her crew numbers about 300 all told, largely composed of Lascars and Seedy boys. The ship sailed on her maiden voyage on the 5th of October. On her trial trip, run from the Clyde to Queenstown, her maximum speed was 18·2 knots, a highly satisfactory result. She has four masts and two funnels.

Her engines very closely resemble those of the Campania and Lucania; that is to say, there are five cylinders driving three cranks. The engines farthest forward and farthest aft are tandem. The central crank is driven by a single cylinder, the intermediate. Thus the two high pressure cylinders exhaust, as shown in our sixth view, into the valve chest of the intermediate cylinder, and that cylinder in turn exhausts into the two low pressure cylinders immediately under the high pressure cylinders. The Atlantic liners have twin screws, the cylinders for each screw being two high pressure 37 in., one intermediate 79 in. and two low pressure 98 in. in diameter. These are intended to indicate about 15,000 indicated horse power, or 30,000 for the two.

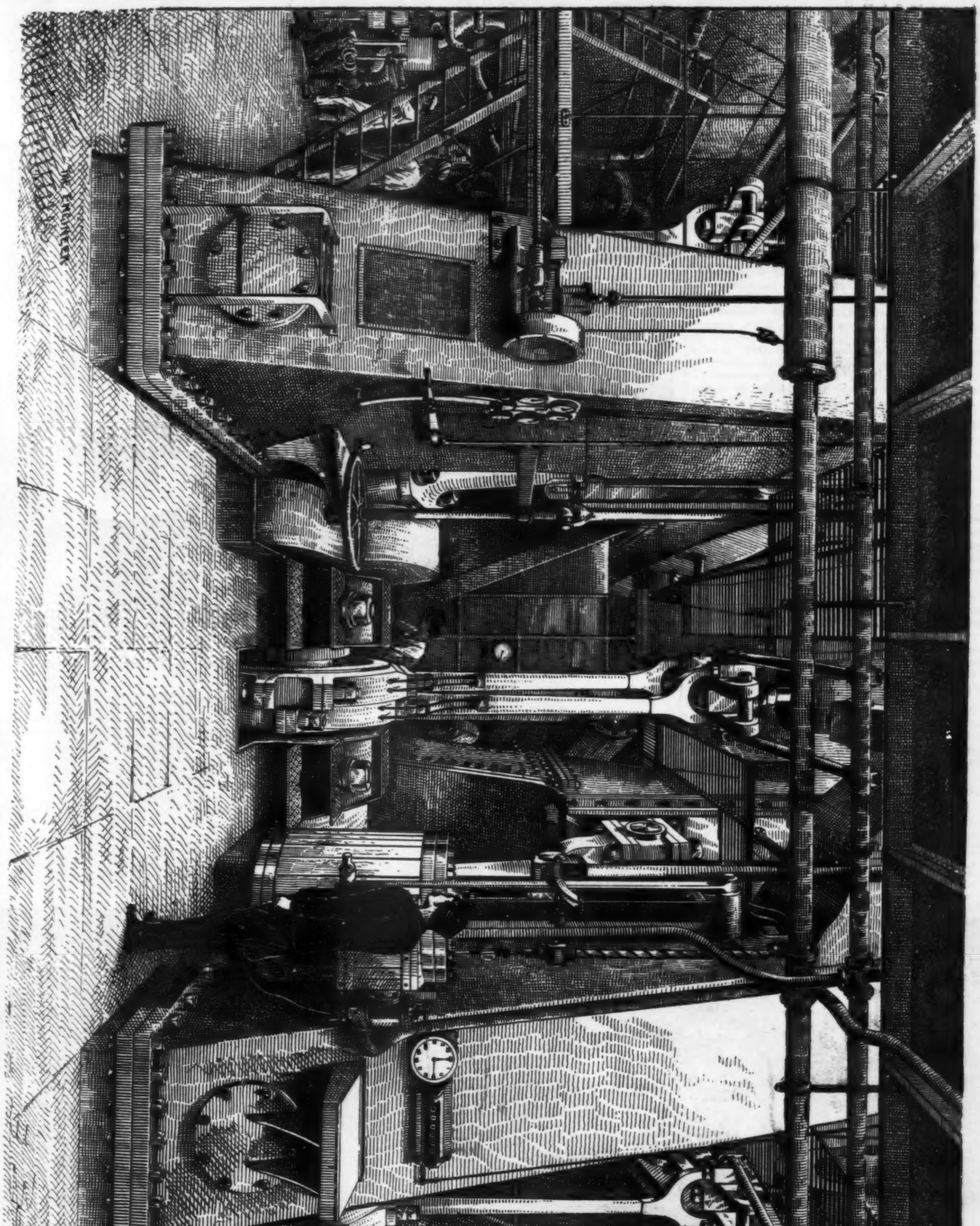
The Caledonia has, as we have said, only one screw. The cylinders are two high pressure, 33 in. diameter,



STEAMER CALEDONIA—ELECTRIC LIGHT ENGINE AND DYNAMO.



CRANK SHAFT—STEAMER CALEDONIA.



ENGINE ROOM OF THE STEAMER CALEDONIA—ON THE LOWER PLATFORM.

one intermediate, 69 in., and two low pressure, 84 in. diameter, which corresponds to one high pressure cylinder, 46¾ in. diameter, one intermediate 69 in. diameter, and one low pressure, 118¾ in. The latter size is too great, and a far better result is got by using five cylinders instead of three. The turning moments are more regular and the risk of a broken cylinder is reduced. The high pressure piston valves are, as we have said, driven off the low pressure valve spindles by rocking levers, as shown. The piston valves might have been placed directly over the low pressure valves, but the ports would then have been much too long and the unbalanced weight would have been very great, the low pressure slide alone weighing nearly 1⅛ tons; as it is, the piston valve partly balances the weight of the slide valve.

The annexed tabular statement gives the principal dimensions of the Caledonia's engines.

The propeller is of manganese bronze and is four-bladed; the diameter over all is 21 ft.; the blade surface is 120 square ft.; the pitch is variable, between 28 ft. 6 in. and 31 ft. 6 in.; when she sailed on her first voyage it was set at 30 ft. 6 in.; the length of blade is 9 ft. 7¾ in.

Steam is supplied by three double and four single ended boilers. They have all the same diameter—15 ft. The total number of fires is thirty. The heating surface in the three double-ended boilers is 14,139 square ft., and the grate surface, 358·8 square ft.; the surface in the four single ended boilers is 9,870·8 square ft., and the grate surface is 229·2 square ft. Thus the total heating surface of all the boilers is 24,000 square ft., which allows nearly 2⅓ square ft. per horse for 11,000 horse power and nearly 16 horse power to the square foot of fire grate.

DIMENSIONS OF THE CALEDONIA'S ENGINES.

Number of cylinders	5
Diameter	33 in., 69 in., 84 in.
Stroke	6 ft.
Diameter of piston rods	11⅛ in.
Valves:	
High pressure	Piston.
Intermediate	Piston.
Low pressure	Slide.
Crosshead pins—diameter	11½ in. × 12 in.
Crank cheeks	17½ in. thick.
Eccentric rods	7 in. at center × 13 ft.
Diameter of thrust shaft*	21⅛ in.
Number of thrust blocks	2
Total number of collars	26
Total surface	6,190 sq. in.
Diameter over collars	28½ in.
Diameter inside collars	21 in.
Length of tunnel bearings	2 ft. 6 in.
Number of tunnel bearings	8
Diameter of tunnel shaft couplers	41 in.

The ship is altogether a very splendid specimen of modern marine naval architecture. We have to express our thanks to the Peninsular and Oriental Company for the facilities afforded to our special artist while making his sketches.

* Lucania's shaft 25½ in.

CONCRETE CONSTRUCTION.

By Mr. Ernest L. Ransome.

THE practical application of concrete may be conveniently divided into four divisions—viz.: 1. False work. 2. Materials. 3. Tools. 4. Labor.

The second division can be usefully divided into four sections—viz.: A. Cement. B. Aggregates. C. Iron. D. Water.

DIVISION 1.

False Work.—Concrete, in respect to false work, is unfortunate in comparison with other masonry, because it not only needs more expensive centering whenever centering is necessary, but it also usually requires cribbing, whereas other masonry does not.

This characteristic entirely prohibits its use in many cases where in all other respects it would be desirable, and it is therefore an obstacle to the more extended use of this valuable construction that should be minimized as much as possible.

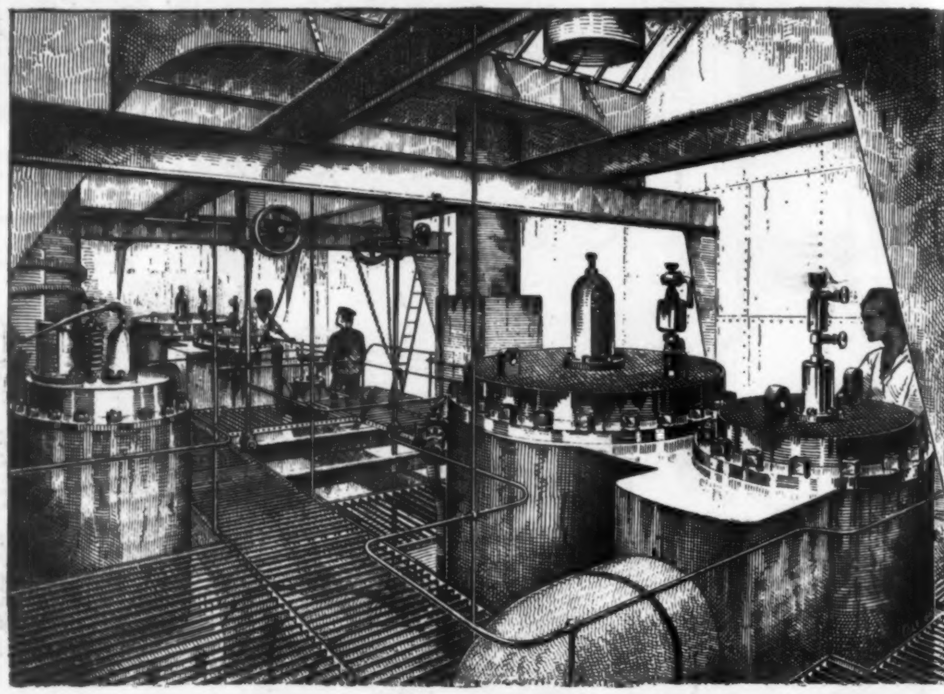
Of late years I have met with considerable success by adopting systems of standard centering and cribbing, which, while not of universal application, are of great use, permitting, as they have done, of the construction of floors and buildings that otherwise could not have been attained; but as this is of interest to the contractor rather than to the architect, I will not enter into a detailed description thereof.

Great difficulties have often arisen from the swelling of the sheeting of the centering or cribbing caused by the wood absorbing the moisture of the newly placed concrete. From this cause many arches have been lifted and broken, floors cracked and walls thrown out of line.

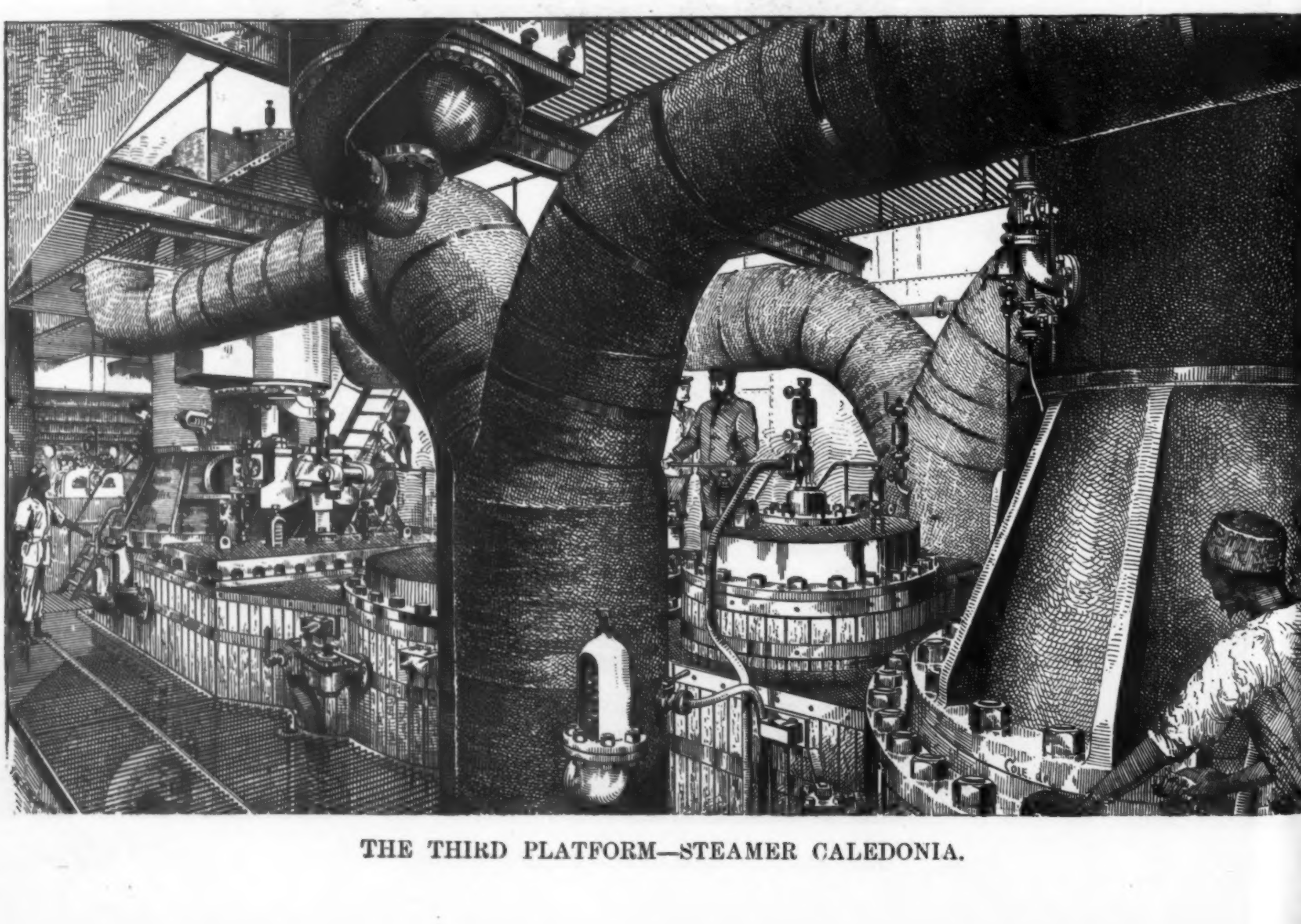
By using sheeting boards of moderate width, say 6 to 8 inches, and beveling one edge slightly, the boards may be put close together, and when expansion occurs the only effect will be to slightly crush the sharp outer edge of the bevel without lifting or disturbing the concrete abutting or resting upon it, the widest side of such boards being of course placed facing the concrete.

This is such a very inexpensive, simple and unfailing remedy that from its conception I have used it in all cases, and since its use I have never had any trouble from swelling of the timber. Some such device as this is especially necessary in dry climates, also in light constructions, such as floors of but an inch or two in thickness, or hollow walls.

For standard centering or cribs, if of wood, it is advisable to make them of planed lumber. The surface of the wood should be thoroughly coated with common thick kerosene oil before it is used for the first time, and before each subsequent use it should be brushed over afresh with the oil, or else with a paste made of castile soap and water. Fish oil is objection-



ON THE TOP PLATFORM.



THE THIRD PLATFORM—STEAMER CALEDONIA.

able, as it is apt to injure the surface of the concrete, and linseed oil is generally too gummy for this purpose.

It may be accepted as a general rule that false work of light sheeting, well braced, is more economical than heavier planks with braces farther apart. I am aware that this is not the usual practice.

The ornamental effect can be much more cheaply produced by recessed than by projected work.

Materials.—Under this head cement, by reason of its greater cost and active qualities, stands out pre-eminent. I will limit my remarks under this subdivision to Portland cement, with the exception of the following observation—viz.:

That where rapidity of construction is not a great object, and aggregates are unusually cheap, by the use of common lime, with or without some of the cheap native cements, properly handled, work of a good quality and astonishing cheapness can be made—1 part of lime to 40 parts of aggregates not being considered too little in some cases.

Portland cement, a giant from its birth, is striding rapidly along in the way of improvement in quality and price, so that formulas of tests that were thought severe a few years ago would not be considered sufficiently exacting at the present time to insure as first class the cement that would successfully pass them.

The current technical literature teems with methods of testing, so that we can hardly go astray in the selection of a good cement. The three principal requisites for a first class cement are as follows:

1. That it sets or hardens without undue expansion or contraction.
2. That it be sufficiently finely ground.
3. That its tensile strength be high.

The usual methods of ascertaining these points are:

1st. The cake test. This test is so well known that a description of it here is unnecessary. When time is an object, by the use of hot water the test may be hastened. Under expert supervision the "boiling test" is by many considered superior to the cake test, but the difficulties in the way of carrying it out, and some uncertainties in the results that yet linger about this new test, prevent me from advocating its substitution for the older test.

2d. The test for fineness. Ninety per cent. of the cement should pass through a 100 mesh screen having 10,000 holes to the inch. It would be better to use a yet finer screen for testing, but for the difficulty of readily obtaining finer screens. The practice of using coarser screens is to be condemned, because they pass much that is inert. The screenings should feel soft and silky to the touch. The residue on the screen should be hard, black, angular grains. The economic importance of fine grinding has seldom been exaggerated. It is usually unduly disregarded, yet it has been established beyond reasonable doubt by repeated experiments that the sand-like grains of the cement are perfectly inert and useless. Still, unlike the first qualification, this is an economic question, and the ill effects of coarse grinding, if not apparent in the first test, can be overcome by making due allowance for the coarse portion in proportioning the cement to the aggregate, and then but little harm will follow the use of coarse-ground cement in ordinary work.

3d. Tensile strength. This test is usually and best made by the aid of the ordinary testing machine. Several first class cements will now develop tensile strengths of 600 or 700 pounds per square inch in seven days, and while this may be too high a standard to insist upon, yet the cement that will not furnish a strength of 450 pounds in seven days ought not, in my judgment, to be graded as first class, unless it is exceptionally fine ground.

With regard to the aggregates not much has been published. Sufficient interest is not usually taken in these inert materials, which, nevertheless, have a powerful influence upon the character of the concrete, so much so that a good aggregate with a poor cement will sometimes give better results than a good cement with a poor aggregate.

A first class aggregate should be made of a hard, tough rock, free from clay or dirt, and having a rough surface and sharp angles when broken; it should be so graded, from the finest grains to the largest pieces admissible in the work it is for, as to give, while retaining the largest proportion of large sized pieces, the smallest proportion of voids.

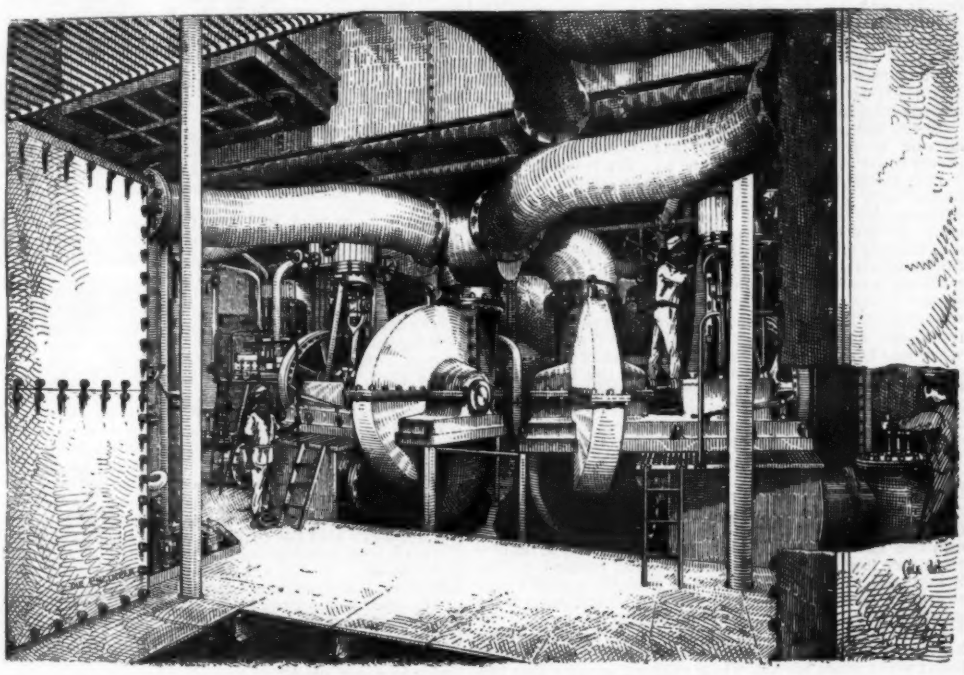
If the aggregate is all of one material, the desired aggregation can be determined by weighing a given measure. That proportion which, while retaining the maximum amount of large pieces, weighs the most is the best.

If, on the other hand, the aggregate is composed of different materials, then that proportion which in a given measure and under the same limitations as just given will permit of the introduction into the filled measure of the least quantity of water is the best.

In making such tests the larger the measure the better; a round measure is better than a square box, and it should not contain less than 2 cubic feet. The material also ought to be shaken down into the measure. It is desirable, when time will permit, to make these tests with a mixture of 1 of cement to 3 of sand; but ordinarily with cements of equal fineness the relative strength of different brands will remain about the same as under the test with neat cement.

For fireproof work care should also be taken to avoid such aggregates as contain feldspar, and where the possibility of the concrete being subjected to a long continued red heat is sufficiently probable as to be worthy of precautions being taken to meet its effects, limestone also should be rejected from the aggregate.

To those who have studied the matter practically, it is evident that in the large majority of cases the prejudice against the use of the dust and finer particles created in crushing brick or stone is unfounded, and the practice of prohibiting these and substituting therefor ordinary sand is strongly to be condemned. Lieut. Innes found that both limestone dust and ground burnt clay gave stronger results than the purest sands, and tests and works carried out under my supervision thoroughly corroborate this.



THE CIRCULATING PUMPS.

The largest stone does not necessarily make the best aggregate. For instance, finely crushed granite is for some purposes inferior to finely crushed limestone, although as a rule the granite is the harder of the two. One reason for this is not hard to seek. Owing to the brittle quality of granite, in crushing it is not only broken into small pieces, but many of these pieces are so bruised or contused that upon a little pressure being exerted upon them, such, for instance, as can be applied by the finger or thumb, they will crumble. With limestone and many other softer rocks, by reason of their greater toughness and elasticity, this is not the case.

Again, some stones, as quartz and the like, have surfaces of such smoothness that the adhesion of the cement thereto is not so good as that between cement and other stone, such as basaltic lava, sandstones and the like, which, when fractured, present a rough surface. Such stones as these latter usually make first class aggregate. Broken stone, as a general thing, is a better aggregate than gravel. Sometimes a mixture of the two is preferable to either alone. Usually the use of one or the other has to be determined by the economic side of the question and the local supply. When from such causes gravel is selected, its quality can be greatly improved, at small cost, by running it through a crusher that will break the larger pieces as they pass.

The common practice of limiting the maximum size pieces so that they will pass through a 3-inch ring is, I think, open to question. In massive work, stones much larger may advantageously be used, not, however, if the late fashionable practice of "dry concrete" is adhered to.

The experiments carried out by Mr. Elliot C. Clarke tend to show that the presence of a small amount of clay in the concrete is no detriment to the strength of concrete, even with clay as much as 10 per cent. of the aggregates and cement combined.

In corroboration of this I would instance the Niagara gravel, which, while it contains a marked quantity of clay, yet makes most excellent concrete.

Having determined the aggregate, the next important question is, What is the proper proportion of cement to use for any given work?

With first class materials, in round figures and within the limits of proportions between the cement and the aggregates of from 1 to 4 to 1 to 14, the crushing strength of concrete, when skillfully made, at a month old may be taken as follows in tons per square foot. Multiply the constant number 700 by the number representing the proportion of cement used, and divide it by the relative number representing the amount of aggregate used. For instance, a concrete composed of 1 part of cement to 14 parts of aggregates should, when properly seasoned, have a crushing strength of $\frac{700 \times 1}{14} = 50$ tons; when three months old the strength will have increased some 25 per cent. and when twelve months old it will have increased some 50 per cent.

Under this rule a concrete composed of 1 of cement to 14 of aggregate would be about on a par with good brickwork when a month old, and about 50 per cent. stronger when twelve months old. This rule reduces the strength of the concrete too much as the proportion of aggregate is increased, but it is reasonably correct and quite safe to act upon.

SECTION C.—IRON.

The tensile strength of concrete is comparatively little, and by reason of the gradual though slight shrinkage that takes place in all concrete structures that age in dry situations, should not be relied upon in any important work.

For giving tensile strength to concrete, all modern workers of note now use iron in some form or other.

Angular iron bars, cold twisted, commend themselves in many ways, and on this continent they have been more largely used than any other form in concrete iron construction.

The advantages of this cold twisting are many. They may be summed up as follows:

1st. The tensile strength of iron is largely increased—viz., from 20 to 50 per cent., dependent upon quality of iron used.

2d. Its elongation under strain is considerably lessened, a very important advantage in concrete iron construction.

3d. It forms a continuous key with the concrete, both longitudinally and also athwart the bar. The effect of the twist is to grip the concrete in every direction, and in fireproof flooring and other work where light construction is desired, the importance of this universal key is very great, for it counteracts the tendency which the bar otherwise would have to split the concrete along the line of tension.

4th. The cost of twisting is nominal, and the royalty for its use not prohibitory.

In placing these bars care should be exercised in putting them in position where they will best exert their strength. They should be straight and laid directly in the line of strain. Any deviation from this rule should be such that the tendency to straighten, which invariably occurs upon the application of the strain, will do little or no damage, such a deviation, for instance, as laying the bar of a floor beam with a slight sag in the center. In such a case, when the strain takes place the tendency to straighten would have the effect of thrusting the center of the bar upward against the downward thrust of the load, and it would be harmless. If on the other hand the bar was laid crowning in the center, upon the floor being loaded, the tendency of the bar to straighten would be in the same direction as that of the downward thrust of the floor load, and the consequences would be detrimental, if not fatal, to the integrity of the structure.

Concrete is an excellent conservator of iron. Von Emperger states that he knows of a case where iron rods were found perfectly rust free after having been embedded in concrete below the water level for 40 years. (T. A. V. C. E., Vol. XXXI., p. 447.)

W. G. Triest, Jr., states that a wrench that had been buried in concrete 22 years had kept its black metallic surface. (T. A. V. C. E., Vol. XXXI., p. 467.)

Referring to some concrete foundations that I built about ten years ago, the president of Starr & Co. writes as follows, under date of December 30, 1893: "Though this foundation is on tide land and submerged in salt water more than half way up, there is no rusting or deterioration to the iron. We had occasion to cut through one of the arches and found the iron as stated." A long time ago I embedded a dozen pieces of hoop iron in as many blocks of concrete, leaving one end of each piece of iron projecting from the surface. After years of exposure to sea air, all the exposed iron had rusted away, or so nearly as to leave but a few soft, jagged needles of rust that were readily removed by the hand. In all cases upon cutting into the blocks I found the iron almost as good as new, and from one to two inches from the surface it was invariably so.

SECTION D.—WATER.

The water for mixing should be clear, and by preference soft. If it cannot be obtained of ordinary purity, then due allowance should be made for the impurities by an additional quantity of cement.

Sufficient water should be used to bring the mass when thoroughly mixed into a stiff, sticky, tenacious, viscous condition. An error as to the amount of water that should be used in concrete some years ago crept in the professional practice both of engineers and architects, and with surprising rapidity permeated and revolutionized it. I allude to the erroneous theory that only sufficient water should be used to slightly moisten the mass, and hardly enough to render it cohesive in its uncompacted state.

An error seldom takes the hold this did upon a skilled body of men without some apparent justification. The only justification that I have been able to find after considerable research is the fact that, in making briquettes for testing purposes, the use of a minimum quantity of water gives the best results. From this one little isolated fact the generalization was made that, to produce the best results, concrete should be mixed in like manner. The fatal flaw in this deduction lies here, viz., that a mixture of cement or of cement and sand, with water, differs radically in conditions when to either of these gravel is added, and differs yet more when broken stone is used.

If cement, or cement and sand, is mixed with a large proportion of water, it cannot be compacted by blows or such pressure as can usually be brought to bear, for the mixture would flow from under the tamper. In the latter case, however, where gravels or broken stone are used, with a larger proportion of water, the concrete can be compacted more intimately and closely than with the minimum quantity, and under all ordinary conditions makes a much better concrete. The only exception to this is where smooth, rounded pebbles only are used with the mortar of the concrete, but this exception does not apply to ordinary gravel and never applies where broken rock is an ingredient. I allude to this at some length, because the error, although on the wane, is still widespread.

DIVISION 3.—TOOLS.

There is great advantage and economy in mill mixing. Mills can now be obtained at a reasonable figure and should always be used on large works. By their use the cement is more fully utilized, the cost of labor lessened and the work is more uniform and satisfactory in character.

An objection is often made to mill-mixed concrete, viz., that the concrete is injured by overmixing. What is "overmixing"? A very rare distemper, this. I have never once met with it, although I have been actively engaged in concrete construction for thirty-five years. It is never epidemic or fatal, but like vaccination, if present, it would prevent worse and more fatal ailments.

Mr. Spencer Newberry found that a mixture of 1 of cement to 3 of sand, which when worked for one minute with a trowel developed a tensile strength of 87 pounds in 7 days, developed a strength of 240 pounds in same period after being worked with the trowel for five minutes, a remarkable result, surely, and well worthy of consideration.

Contrary to the almost universal opinion, Portland cement is improved by a delay between mixing and placing. I have experimented with several brands of Portland cement, and find that they were invariably improved in tensile strength by a delay of from 1 to 4 hours between mixing and placing.

In placing concrete it is preferable to have it of one uniform consistency throughout the mass. In cases, however, where it is required that the face of the work should be of a finer grade, both grades should be carried on simultaneously, the face grade being placed up against the sheeting or mould a little in advance of the backing by means of a trowel or other convenient tool. In more careful work thin strips of iron about six inches wide and of any lengths convenient may be set upon edge in the concrete parallel to and at any desirable distance from the face of the mould. The face concrete should then be inserted between the mould face and the iron while the backing is placed at the other side thereof. As each layer is put in the iron is drawn up a few inches, so that when the concrete is tamped the effect of the tamping is conveyed below the lower edge of the iron, and causes the two grades of the concrete to become thoroughly united and monolithic.

The material should in ordinary cases be placed in thin layers seldom greatly exceeding in depth the length of the largest aggregates used, and these layers should follow one another sufficiently quickly so that one layer does not become stiff or partially set before the next is upon it.

Flat tampers should not be used for massive work, except in the first and last layers of the day's work; thin or edge tampers should be employed. Wherever practicable, the concrete should be compacted by rolling, in preference to tamping. It is cheaper and much more effective. I am not aware of its being done outside of my own practice, but it is certainly deserving of almost universal use. On large work steam rollers would be excellent.

It may be accepted as an axiom that concrete cannot be too thoroughly compacted, provided the action is not violent enough to bruise or crush the aggregate.

In massive or deep work, as it proceeds through the day, often the working surface becomes richer in mortar, when, and as often as this occurs, the mixture should be changed by adding thereto more of the larger aggregates free from fine dust, sand or gravel, until this fault is remedied. If, on the contrary, at any time the surface becomes open for lack of mortar, it should be immediately remedied by putting into the mixture a lesser quantity of the larger aggregates and not substituting anything in their place.

In a similar way the amount of water used in the mixings should be regulated, changing to more or less as the working surface appears too stiff or too watery. It should be firm under the tamper or roller and yet the mortar should be viscous and unctuous to the touch.

The quantity required to produce this condition varies greatly, dependent upon the character of the aggregates, whether but slightly or very porous, and upon the age and character of the cement and weather.

Great care should be observed in joining the work of one day to that of the next. The last layer should be thoroughly compacted and left with a slight excess of mortar. It should be finished with a level surface, which at proper time, as soon as sufficiently stiff, should be patted or stippled with a steel float so as to produce a surface studded thickly with little conical knobs. This surface should be kept wet throughout the night, and in the morning immediately before the application of the first layer of fresh concrete it should be covered with a wash consisting of a mixture of equal measures of Portland cement and air-slaked lime, mixed with water to the consistency of thick cream. This covering should be put on in excess and brushed thoroughly back and forth upon the surface so as to insure a close contact therewith, the excess being swept along just ahead of the fresh concrete until all the surface has been covered, when it should be removed.

When in place the concrete should be kept moist for as long a period of time as possible. When one bears in mind that the chemical action which causes the cement to harden can only take place in the presence of moisture, the importance of keeping the work wet is at once apparent. In all concrete construction, excepting subway and other works where the concrete remains permanently moist, provision should be made for the slow but certain shrinkage that takes place in the concrete as it becomes thoroughly dehydrated. The vertical shrinkage will take care of itself, as the weight of the building is in harmony with its movement. The horizontal shrinkage, however, is resisted by the inertia of the structure and the friction of its foundation. There are several ways to direct such shrinkage; that which I have found most feasible is to partially divide the wall at certain intervals, preferably over the windows where there are several in line, and to insert across the division a weathering strip of copper or lead.

Where the appearance of a straight division line on the face of the building would be objectionable, for instance, a wall blocked off into ashlar face, I build this division straight and cause it to coincide with the line of the V recesses of the ashlar, marking in every other course, and I block out in the intermediate courses recesses opposite to the division line, and subsequently fill these recesses with concrete ashlars made and seasoned beforehand. By adopting the pattern of alternate long and short ashlars in every other course with long ashlars only in the immediate course meeting at the center line of the short ashlars above and below them, these separate concrete ashlars may be made small, and the additional cost of their manufacture will be but trifling.

Apart from the question of appearance, some such division of the surface of a concrete wall is advisable for a twofold reason; some defining line is needed at the juncture of each day's work at least, and by dividing up the surface by deep recesses into small sections, surface cracking is largely avoided.

In reference to this shrinkage of concrete, lest I should have unnecessarily alarmed you, I will state that in a building, the walls of which were 170 feet long and divided thus, it was nearly two years before any apparent shrinkage took place, and now it can hardly be observed by a minute examination of the division joints. No outsider, even though a careful observer, would be likely to perceive any effects of this slight shrinkage when thus controlled.

In situations where it is not possible to make shrinkage joints, by a liberal use of twisted iron, shrinkage cracks can often be prevented.

The Resistance of Portland Cement Concrete to the Destroying Action of Fire.—By a misunderstanding, due to a windy interference (Mr. Stone tells me one of my letters was blown out of his office window), I find I am expected to speak on the protection concrete affords iron in case of fire.

There seems to be not so much data on this subject as one would desire. What little there is, however, seems to be in favor of concrete as a fire resistant.

It is generally understood that the artificial stone made with Portland cement concrete withstood the Chicago fire well. Some years ago the blacksmith's shop at the Benecia Arsenal, California, was burned out, leaving the outer walls standing. This was a brick building with granite door sills, freestone belt courses, with window caps and cornice of Portland cement concrete. I examined the ruins carefully. The granite was spoiled badly and broken into several pieces; the freestone was badly broken and injured; the brickwork was burned out in the joints in many places, rendering the walls unsuitable, many of the bricks also being spoiled, while the concrete window heads, which had probably to bear the brunt of the fire on the outside, were but little injured; the surfaces had softened a little and were badly discolored, but they remained whole and strong.

Concrete bricks, made of well burned clinker and lime by a process which converts the lime into a silicate of lime, thereby making it resemble a Portland cement in character, withstand the action of a hot fire and the subsequent sudden cooling by water better than any burned brick, either common pressed or fire brick, that I could obtain in San Francisco, and I presume the same relative result would be obtained from most of the bricks of the several States.

I have repeatedly made the tests so severe that every burned brick in the dozen or so tested at a time broke into two or more pieces, while under the same test the concrete bricks, beyond discoloring slightly, showed no change.

The Thermic Expansion of Portland Cement.—Bonnican Bonnicean is quoted as giving the expansion of Portland cement at 0·00000143 for 1 Celsius, and iron is given at 0·00000145, which is practically the same.

Hyatt corroborates this in some careful experiments he made with loaded floors submitted to fire, in which the concrete-iron construction bore a red heat for several hours without injury.

Throughout Europe, I believe, hollow tile construction is almost unknown. Concrete floors are commonly used in fireproof buildings. The result of tests undertaken in Germany under government supervision to ascertain the relative value of the ordinary building material, including brickwork, places concrete at the head of the list as the best fire resistant.

If due regard is paid to the aggregate used, so that feldspar is avoided, and limestone also, where the structure is liable to prolonged hot fire, I think it will be found that Portland cement concrete is an excellent fire resistant.

THE SIMPLON TUNNEL.*

THE project for tunneling the Simplon has recently taken a more definite shape. Out of a great many propositions for crossing the Alps underneath the Monte Leone, a plan has been evolved which has been approved by the Swiss government. On the strength of this plan, in September, 1893, a contract was consummated between the Jura-Simplon Railroad and the contracting firm of Brandt, Brandan & Company, in Hamburg, as noted in the Railroad Gazette of November 3, 1893.

Alignment and Elevations.—The proposed Simplon project leaves on Swiss territory the village of Brieg on the Rhone River, the present terminus of the railroad on that side of the pass, and follows the left shore of the river for a little over 1¼ miles to the northern portal of the great tunnel. The tunnel traverses the Monte Leone in the direction northwest-southeast, in a length of 64,718 ft., or 12¼ miles, when it reaches the southern portal on the left bank of the Diveria, a little below the village of Iselle and about 16 miles from Domo d'Ossola, the present terminus of the Italian railroads. The parting line of the watershed, which at the same time forms the frontier between Switzerland and Italy, is crossed at nearly right angles, 5·65 miles from the northern portal. The tunnel deviates from a straight line at both ends in order to make proper connections with the open road. The northern portal is 174 ft. higher than the southern portal, and the tunnel in consequence rises from the north with a grade of 0·2 per cent., the minimum permissible grade for drainage, to the center, in order not to have a steeper grade than 0·7 per cent. on the southern half.

* Abstract from the Schweizerische Bauzeitung, by W. G. Triest, Jr., Am. Soc. C.E.—Railroad Gazette

The tunnel will be the longest in the world, as the following table shows:

	Mont Cenis.	Gothard.	Arlberg.	Simplon.
	Feet.	Feet.	Feet.	Feet.
Length of tunnel......	42,145	49,148	33,587	64,718
Time when built......	1857-1870	1873-1880	1880-1883	....
Elevation of north or east portals........	Feet. 3,765	Feet. 3,637	Feet. 4,270	Feet. [illegible]
Elevation of south or west portals........	4,162	3,756	3,995	2,079
Elevation of culmination point........	4,247	3,788	4,300	2,312
Maximum grade........	Per cent. 2·2	Per cent. 0·58	Per cent. 1·5	Per cent. 0·7
Maximum thickness of overlying rock........	Feet. 5,425	Feet. 5,586	Feet. 2,361	Feet. 7,005
Maximum temperature of rock........	85° F.	87½° F.	66⅛° F.	104° F.

The Hoosac tunnel in Massachusetts was built in 1854 to 1870 and is about 4¾ miles long.

Tunnel Profiles.—Abandoning the plan of the existing tunnels through the Alps, which are all double tracked, two single track tunnels, 58 ft. between centers, are contemplated for the Simplon. The single track, lined tunnel profile has a clear section of 277 sq. yds. The clear width at the elevation of ties is 14 ft. 9 in., and 16 ft. 5 in. at a height of 6½ ft. above ties. The head room is 18 ft. Five profiles are provided as follows:

Profile I, not lined, for rock without pressure and of uniform stratification.

Profile II, in rock of irregular stratification requiring a mere lining; haunches and arch of ashlar 1 ft. thick.

Profile III, in rock with medium strong pressure; haunches of ashlar, arch of cut stone 20 in. thick.

Profile IV, in rock with heavy vertical pressure, haunches of coursed ashlar, arches of cut stone, 2 ft. thick.

Profile V, in rock with great lateral pressure and in deteriorated rock; haunches of coursed ashlar, 32 in. thick, inverted arch of 16 in., and arch of 24 in. thickness.

Along one side of the tunnel, every 328 ft., small arches will be provided, 6½ ft. wide and 7½ ft. high. Every tenth of them will be made somewhat larger for bell signals and lamps. There will be four large chambers at uniform distances, for storing the tools of the track crew. In the center, a siding of 1,312 ft. length is provided for passing trains.

Geological Profile.—In the Simplon, the sequence of the geological age is uninterrupted from the south to the north, the tunnel going in a stretch of 12¼ miles through margarite chalk, gneiss, mica and gypsum. The strata will cross the axis of the tunnel nearly at right angles, but their dip is variable. The rock is well adapted for mechanical drilling; in the mica of the northern end the drilling will progress rapidly, as the rock is of less hardness, and as the stratification is favorable. In the central mass, which is of greater hardness, the desired progress can be safely expected, as the rock is compact for great lengths. The gypsum and dolomite strata are the most dangerous ones for the advancement of the tunnel, but they occur in short lengths only. Water is to be expected in the interior in some places.

For 6⅛ miles the rock temperature will surpass that of the Gothard tunnel 87½ deg. and will reach a maximum of about 104 deg. It is proposed to lower the temperature in the Simplon tunnel by ample ventilation and by cold water sprayed under high pressure. For each end an air current of 1,760 cu. ft. per second will be provided, while, in 1878, in the Gothard tunnel, only 71 cu. ft. were used. The air temperature is to be cooled to 90 deg. and the conditions for working will thus become more favorable than in the Gothard tunnel.

Water Power.—The investigation of available water power for the installations has given the following results. At the northern end the Rhone affords a sufficient and reliable volume of water. The construction of one race will give a normal power of 840 horse power, with a maximum power of 1,180 horse power. An additional race would increase this to 1,380 horse power normally, and to a maximum of 2,360 horse power. At the south end the Cairasca River will give a normal power of 1,690 horse power and a maximum of 2,200 horse power.

Contract.—The contract for the construction of the Simplon tunnel provides:

For the power installations, $1,251,000; for tunnel I, complete, with parallel gallery, $9,040,000; for tunnel II, completed, $2,941,000. Total for two single track tunnels, $13,232,000. In the above sums are not comprised the acquisition of right of way for the power installations, the track material for the two single track tunnels, nor the ballasting of tunnel II. The first single track tunnel must be finished within 5½ years, and the time of construction of the second tunnel is fixed at four years. If the second tunnel is not ordered to be built within four years after the completion of the first one, the contractors are released from the obligation of building it. The contractors in signing the agreement have deposited $200,000, which guarantee bond will gradually be raised to $1,000,000 during the progress of the work. A fine of $1,000 a day is fixed for each day that the work is delayed beyond the stipulated time, and an equal bonus will be paid for each day gained. The tunnel is to be built at the exclusive risk of the contractors, who are also responsible for the laying out of its axis. The contract provides no remuneration for an unforeseen increase of the difficulties by water pressure, higher tempera-

tures of the rock, etc.; wars, strikes, or epidemics excepted.

General Mode of Construction.—The former projects for a Simplon tunnel were based on the known methods of tunneling, and on account of the great warmth which was to be expected in the interior of the mountain, doubts were had as to its practicability. The method of building two single track tunnels instead of one double track one is entirely novel. From the beginning, two galleries will be driven from each end as the basis of the two tunnels, and will be connected by transverse galleries every 660 ft. One gallery, in the profile of tunnel I, will be immediately enlarged to the full tunnel section, while tunnel II will be completed only when the first tunnel does not suffice any longer for the traffic. The clear section of gallery II, 86 sq. ft., is used for ventilation. Its entrance is closed by a door, and air is blown into the gallery by powerful ventilators. The transverse galleries are closed, except the two which are temporarily open, the two forward ones, so that the air current is compelled to pass in through gallery II and out through gallery I and tunnel I, thus ventilating the principal workings. An ample and reliable ventilation is secured in this manner. Gallery II serves further for draining, through a large canal, the natural tunnel water as well as that which has been led in. The excavated material of tunnel I will be taken out through tunnel I, in trains which, empty, pass into it through gallery II and the transverse galleries. With the help of gallery II, the most difficult questions in the construction of long tunnels find a very favorable solution. Tunnel II can be built out in the same way without molesting traffic in tunnel I. Repairs of tunnel I, while it only is being operated, will not cause any greater difficulties than in a single track tunnel of 660 ft. length. Workmen and materials will pass through gallery II, and the nearest transverse galleries will serve as entrances to the working site.

Galleries I and II are driven simultaneously by Brandt hydraulic drills. At each heading work three to four drills, to which pressure water is fed through one 4-in. pipe line in each gallery. For the slate in the first half of the northern end, a water pressure of 1,026 lb. per sq. in., and for the gneiss of the second half one of 1,456 lb. per sq. in. is provided.

Besides these, six to eight drills for the headings, further four drills are contemplated. This maximum of twelve drills requires per second 4·7 gallons of water of 1 026 or 1,466 lb. working pressure. The mean daily progress which has to be reached as a minimum with the drills in full working order has to be somewhat over 19 ft., a progress which seems to be guaranteed by the experiences in other tunnels. In the Arlberg tunnel, the Brandt hydraulic drills averaged $18\frac{1}{2}$ ft. daily; in the Suram tunnel, in the Caucasus, a progress of $19\frac{3}{4}$ ft. per day was attained in the sandstone and chalk. The improvements of the drills have succeeded in materially shortening the drilling period for one blast, while the stronger explosives increased the efficiency of the blasts.

It becomes now important to reduce also the time consumed in removing the blasted work. Many unsuccessful methods have been devised to mechanically carry the blasted rock backward, but the simplest method, that of loading directly into cars, remained the best one. The contractors expect, however, to make a considerable saving in time by throwing the blasted rock backward with hydraulic power at the moment of the explosion. Thus the rock, of which ordinarily the greatest part lies within a few feet from the bench, thus delaying the new setting up of the drills, is distributed over a greater length of the gallery, and the space for the drills is more quickly cleared. A further advantage is the simultaneous and very energetic cooling of the debris and of the gallery. Experiments with this new method have given surprisingly good results. The looked-for saving in time has not been taken into the calculation, but it is regarded as a reserve for unexpected delays.

For the transport of debris out of the tunnel and of tools and materials into it, tracks of 2 ft. $7\frac{1}{2}$ in. gauge are used, laid with 40 lb. rails. Each gallery will have one track, and the tracks are to be connected by switches through the transverse galleries. For this reason the cross galleries are built inclined to the tunnel axis. Steam locomotives, weight in service 16 tons, will be used, capable of passing 50 ft. curves. They will have very large boilers, so as to make the upgrade trip into the tunnel with little or no firing.

The dump cars, of 70 cu. ft. capacity, will have metal frames with springs, buffers and elastic draught gear. Each car will have three seats in the front and rear, as after the second year it will be necessary to take the men in and out on trains. The trains will generally enter through gallery II and leave through gallery I, thus going in the same direction as the ventilating current. In entering, the trains will be pushed, on account of the switching through the transverse galleries, and in order not to trouble the passengers with smoke. At each transverse gallery the locomotive will push as many cars into gallery I as the adjoining working sites require. Before the arrival of a train in the tunnel, the cars which are ready for removal are shoved by hand into the nearest finished tunnel section, from where they are later taken out by the locomotive.

The principal ventilation will consist, as said above, in blowing a large quantity of air into gallery II and out through gallery I and tunnel I. The air current is incidentally intended to cool the rock. For ventilation, 53 to 71 cu. ft. per second were used in the Gothard and 106 to 212 cu. ft. in the Arlberg tunnel. The working conditions with the last named air volume were very satisfactory. In the Simplon a maximum of 1,760 cu. ft. is contemplated, which would give a velocity of nearly 20 ft. per second. Such a large air volume will doubtless result in a quick and efficient cooling of the rock, and a further cooling will not be required in the working sites through which the current passes. If necessary, the air could be cooled by water sprays. To drive 1,760 cu. ft. per second through a gallery of $2\frac{1}{4}$ miles length and 86 sq. ft. section, a hydrostatic pressure of 18·64 in. is necessary, for which have to be added 0·56 in. for loss by friction. To procure such a volume of air at this pressure, 500 horse power is required at the ventilator shaft, the efficiency of the ventilators taken at 65 per cent. Beside each tunnel portal two fans of 18 ft. diameter are placed, coupled separately to turbines. Each pair can be coupled to furnish either 1,760 cu. ft. at 19·2 in. pressure or double the quantity at half the pressure. The working sites which lie beyond reach of the air current are ventilated as follows: Into the lower galleries I and II water injectors drive air through flues from the last transverse gallery. The water cools the air simultaneously. In equal manner the top galleries of tunnel I are ventilated from the lower gallery I. A calculation of the heat which has to be drawn from the rock in order to lower its temperature to 58° shows that $12\frac{1}{2}$ gallons per second are necessary, if the cooling influence of the ventilating air is disregarded; $17\frac{1}{2}$ gallons per second are provided, and it may consequently be regarded as safe that the temperature in the middle of the tunnel will never be unbearable. The 10 in. pipe line which carries water into the tunnel is laid in gallery II. At the last temporary cross gallery, one branch carries the water forward for the hydraulic handling of the debris, another branch passes through the cross gallery and is divided into two arms, of which one goes forward for hydraulic, the other backward for cooling purposes.

Power Installation at the Tunnel Entrances.—At the north end the installation will be placed on the left shore of the Rhone. Three construction periods are contemplated in the mechanical installations. In the first period of one year, during which the water power will be procured and the building erected, 140 horse power will be required for driving six hydraulic drills at 1,026 lb. per sq. in. pressure and 80 horse power for ventilation. This power will be furnished by three transportable engines. The second period will last $1\frac{1}{2}$ to 2 years and ends when station kilometer five is reached. During the same 750 horse power is necessary, divided among the operation of drills, fans, electric light plant and workshops. During these two periods a shaft of $6\frac{1}{2}$ ft. diameter is to be sunk vertically over station kilometer five down to the tunnel, a distance of about 2,300 ft. Through this shaft a volume of water from the Steinebach, 24 gallons per second, is to be carried for drilling and cooling purposes. The last period comprises 2 to $2\frac{1}{2}$ years and requires 500 horse power for ventilation, 200 horse power for electric lighting and 100 horse power for workshops. This power, as likewise that of the second period, is furnished by the Rhone.

At the southern end the narrow valley of the Diveria and its steep grade make an installation inconvenient, and both shores have to be utilized. Two working periods have to be considered. In the first year, during which the water power is being made obtainable, 180 horse power is required for driving six hydraulic drills at 1,466 lb. per sq. in. pressure and 30 horse power for ventilation. This is furnished by three transportable engines. In the second period, which lasts 4 to $4\frac{1}{2}$ years, there is needed 850 horse power for 10 drills with $1\frac{1}{15}$ qt. per second at 1,760 lb. per sq. in., 550 horse power for cooling purposes and hydraulic removal of debris, 500 horse power for ventilation, 200 horse power for electric lighting, 100 horse power for workshops, etc., a total of 1,700 horse power, which will be taken either from the Diveria or from the Cairasca.

The Ventilation During Operation of Tunnel.—In single track tunnels of the length of the Simplon tunnels reliance cannot be placed on the change of atmospheric pressure alone by which the existing tunnels are ventilated by creating sufficient air currents. On some days the natural ventilation may be perfectly quiescent and the air in the tunnel will be injuriously vitiated by the accumulation of smoke. In the Gothard tunnel the air is said to remain practically motionless for 12 hours of the day, during which a great amount of carbonic acid is delivered into this stationary atmosphere; while a great part of it is taken up at once by the water, there still remains suspended in the air enough to render it harmful for breathing. Further, the corrosion of the metal work is very rapid. In the Arlberg tunnel the metal structure had to be renewed entirely after ten years. For these reasons it is proposed to ventilate the Simplon tunnel artificially. The same ventilators are to be used which will serve during construction. As long as only tunnel I is in operation, it is contemplated to introduce 1,760 cu. ft. air per second from the north ends. The north portal will be closed by a door. When both tunnels are used, air will be blown into tunnel I from the northern end and into tunnel II from the southern end, while the north and south portals respectively of the two tunnels will be closed by doors. The air current will thus have the same direction as the trains.

Sanitary Arrangements.—As near to the tunnel portals as possible barracks will be built containing bathrooms, dressing rooms, laundry and restaurant. The workingmen receive from the contractors special working clothes, which, when not used, are kept in the barracks. The working clothes are returned after working hours to be cleaned and dried.

The Expert Report.—To examine and report on the Simplon tunnel project, as described above, the Swiss government appointed a board of experts in April, 1894. This board consisted of Messrs. Francis Fox, of London, Karl Johann Wagner, of Vienna, formerly division engineer of the Arlberg tunnel, and Guiseppe Colombo, professor in the Polytechnic School of Milan. Twelve questions were put to them, relating mainly to the construction, ventilation and operation of the tunnel. The board submitted their report in July. They report favorably on the possibility of obtaining sufficient water power from the numerous brooks and rivers, especially as the low elevation of the tunnel gives them a great head of water. Regarding the installation, it is considered as desirable that the daily progress be increased beyond the proposed rate during the second period of construction, in order not to rush too much the remainder of the gallery work. They recommend that the distance of the tunnel walls from the axis be made at least 7 ft. $8\frac{1}{2}$ in., so as to afford more standing room to employes during the passing of trains. The distance of 56 ft. between tunnel centers is believed sufficient, as the rock is stratified nearly vertically to the tunnel axis. With the exercise of care it is, therefore, not to be feared that the parallel cavities to be created will influence each other unfavorably. The programme for the execution of the work may be followed almost without alteration. For such long tunnels hydraulic transmission of power must at present be given preference, decidedly as the losses are smaller than with other systems, and as a maximum effect of machine drilling in the hardest Simplon gneiss is obtainable.

From the experiences in the Arlberg tunnel the Brandt system of revolving drills with hydraulic transmission is preferable to all other systems. The board does not consider as feasible that the locomotives in transporting construction trains through gallery II can make the trip of about six miles without renewing the steam pressure by firing. In order not to vitiate the entering ventilating current in gallery II by the locomotive gases, it is recommended to switch the locomotives temporarily through the transverse galleries into tunnel I, where the firing can be done. The proposed methods of ventilation were approved in the principal features. The question whether the operation of a single track tunnel with parallel gallery and artificial ventilation is feasible is answered in the affirmative, provided that the parallel gallery and the transverse galleries are lined with masonry wherever the nature of the rock requires, so as to exclude an interruption of the ventilation by a cave-in; it is further necessary that the locomotives attain a perfect combustion. As the capacity of one single track tunnel under the circumstances, the experts give an average of 12 passenger and of 30 freight trains a day. The report recommends electric propulsion of the locomotives for the operation of the tunnel, as the vitiating of the air and the rapid corrosion of the track material would be obviated. The existing water power at both ends of the tunnel would render the conditions for an electric installation very favorable.

In conclusion the experts state that with the observance of care and precaution the construction as well as the operation of the Simplon tunnel will not offer particular difficulties.

THE AMSLER TACHYMETER.

DR. ALFRED AMSLER, son of the celebrated mechanician of Schaffhausen, at the last meeting of the Swiss Society of Natural Sciences, exhibited a tachymeter, the construction of which was based upon a well known principle of kinematics which he applies in a very ingenious manner to the comparison of two rotary motions.

Let us consider a sphere free to move in all directions (Fig. 1, details in outline), to which we communicate a uniform rotary motion by means of a wheel

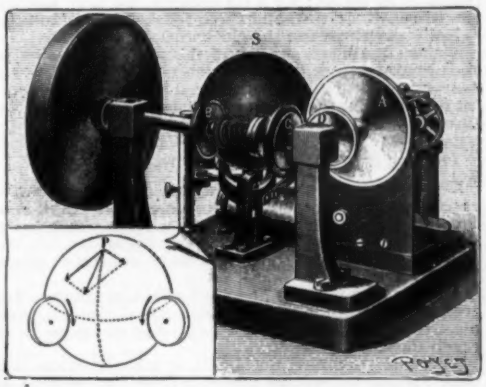


FIG. 1.—Amsler Tachymeter seen at the side on which the wheels A and B are placed. The diagram in the lower left hand corner explains the principle upon which the apparatus is constructed.

movable around a horizontal axis. Now, by means of another wheel, let us attack the sphere at a point situated at right angles with the first. The sphere will take on a combined motion around a third horizontal axis forming a certain angle with each of the two others.

The velocity of the rotation will depend upon the absolute velocity of the two motions, but its direction will depend only upon their relative velocities. Such direction may be determined à priori by applying to the pole, P, of the great circle passing through the points of attack the theorem of the parallelogram of the velocities in a plane. It will suffice after this to determine the direction of this axis in order to know at once the ratio of the two velocities. If the first is known and given, for example, by a clockwork movement, the second will be immediately deduced therefrom.

This granted, the following is a description of the apparatus: The brass sphere, S (Figs. 1 and 2), is placed upon the small wheel, G, and rests upon the disks, A, B and E. The latter, whose support is movable around a vertical axis, serves solely for maintaining it in place, while the first two communicate motion to it. The disk, A (Fig. 1), actuated by a clockwork movement with spring escapements, gives the rotation of comparison, while the disk, B, moved by the engine whose velocity we wish to know, deflects the instantaneous axis of rotation to a degree so much the greater in proportion as its motion is more rapid. These two disks, which are made of unequal size for the convenience of constructing the motor, correspond to the two wheels of the diagram.

It is a question now of determining the instantaneous axis of rotation, and it is here that intervenes a new principle, which might be enunciated by saying that nature is a careful economist.

If the sphere, S, rested upon small balls, each of them would take on a motion such that, at the point of contact with the sphere, it would undergo no sliding. The friction would be reduced to its minimum by a simple rolling. Let us replace the ball by the wheel, G. The latter will seek also to economize work, and will so place itself as to roll over the sphere without sliding. Its axis will then be parallel with the instantaneous axis of rotation of the sphere, and will serve to indicate it. This wheel is mounted upon a device movable around a vertical axis placed beneath the center of the sphere. It carries along this device and likewise a

needle, which indicates upon a dial the velocity of the motor at each instant of its operation.

Of course, the instrument may be completed by a registering apparatus that will permit of following the entire operation of the engine.

In Fig. 2 will be seen a drum that carries a sheet of paper, upon which the indicating needle inscribes its position.

In order to simplify the construction of the instrument, the clockwork movement has not been provided with a motive spring, and its role has been reduced to that of a regulator. All this part of the instrument is actuated by the wheel, D, which receives its motion from the wheel, C. These two disks rub one against the other in such a way that whatever be the velocity of C, the wheel, D, cannot take on a velocity greater than that permitted by the escapement. Finally, there will be seen upon the shaft carrying the wheels, B and C, the driving pulley that receives its motion from the

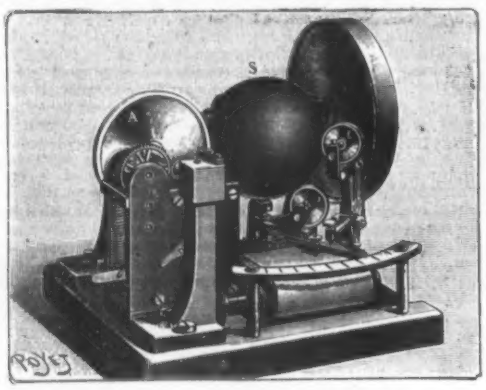


Fig. 2.—The Tachymeter seen at the side on which the receiving part, G, of the clockwork movement is placed.

engine whose velocity it is desired to know. This pulley may be exchanged at will, so as to utilize the apparatus in the regions of maximum sensitiveness.

The instrument is easily verified at the two extreme points of its travel; for a nil velocity, by first leaving the wheel, B, at rest, and then, for a virtually infinite velocity, by throwing the clockwork out of gear.

We are unable to say what the industrial value of the apparatus just described may be, but it has appeared to us worthy of being presented to our readers by reason of the ingenuity of its construction.—La Nature.

THE AUTOMOBILE BICYCLE.

The essentially original thing about the locomotive apparatus that we are about to describe is that, contrary to what has happened with so many wonderful inventions of this kind that have never had life, except in the brains of those who have conceived them, it really works!

At least fifty bicycles provided with a gasoline motor are already running in the vicinity of Munich, their place of origin, and in a few days one of them is to reach Paris.

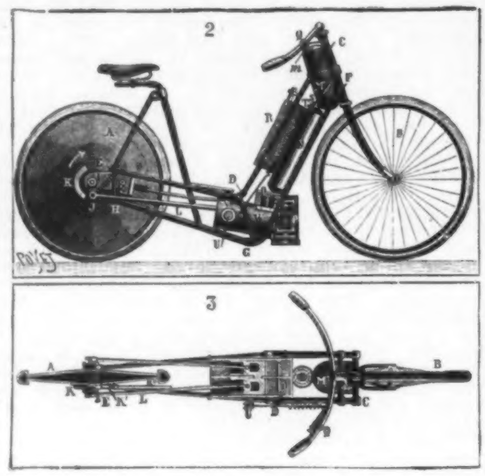
There is, therefore, no longer any doubt of the fact that cycling by manual power is from the present to have a rival, whose future it is difficult not to recognize, and that is cycling by the power of a mechanical motor. The bicycle that we have here marks the entrance upon the stage of a new carrying apparatus intermediate between petroleum carriages and cycling machines. The aspect of Messrs. Wolfmuller and Geisenhof's gasoline motor bicycle (Fig. 1) is that of an ordinary wheel of the lady's type, with exaggerated dimensions. Upon looking at it, the eye is struck by two peculiarities. The hind wheel is not, like the front one, mounted with spokes, but is solid and formed of two disks; and the machine is lower than our ordinary models. The first peculiarity is justified by the resistance that it is necessary to give a wheel, light upon the whole, that is actuated by two pistons which

Fig. 1.—THE GASOLINE MOTOR BICYCLE.

sometimes furnish as high as 2½ horse power. The second is explained by the absence of cranks. So the rider, seated on the saddle and his two feet placed at the sides of the frame upon stationary stirrups, has only to stretch out his legs to find the ground.

The steering is done as in the ordinary bicycle, and with so much the more ease and fewer chances of sliding in that the center of gravity of the apparatus is placed much lower than usual. The total weight of the vehicle is nevertheless not great, since, when ready to operate for long stretches, it does not exceed 110 lb. Let us add that the speed is easily regulated at from 3 to 24 miles an hour by means of a button placed under the thumb of the rider, that the noise and odor of the motor are almost nil, that powerful brakes render the cyclist always master of his machine, even in the steepest descents, and that, finally, so many valuable improvements are already united in this invention, which has not yet reached its perfection, that it is bound to meet with many doubting Thomases.

If we remove the covering plates from this bicycle, we first come across (Fig. 2) quite a complicated mechanical apparatus, the too numerous details of which we have simplified for the clearness of description. The frame of the machine is formed of eight tubes,



Figs. 2 and 3.—MECHANISM OF THE GASOLINE MOTOR BICYCLE.

Details of the operation. Side and plan views. A, driving wheel; B, steering wheel; C, D, E, F, G, H, frame tubes; M, gasoline reservoir; N, evaporator; O, valve box; P, lamp and ignition chamber; p, ignition tube; R, water reservoir; S, cock for regulating the entrance of gasoline into the evaporator; T, funnel of the evaporator; U, regulator of water for cooling the cylinders; V, distributing mechanism; W, cylinders; I J, connecting rod; K, cam; K′, roller; K″, rod of the distributing mechanism; L, piston.

four on each side (CD, DE, FG, GH, for example, on the right side) connected by various crosspieces (such as GD and EH) that consolidate them. These tubes are not brazed together as in bicycle construction, but are simply assembled by sockets, D, G, etc., in a tight manner, since they communicate with one another and serve for the circulation either of the water necessary for the cooling of the cylinders or of the oil to reduce friction.

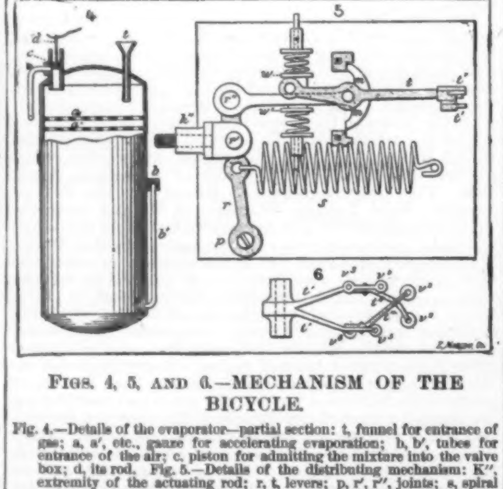
The wheels are provided with pneumatic tires. The steering wheel, B, oscillates as usual around the axis, CF. The driving wheel, A, whose center is at I, is provided with a firmly fixed cam, K, the use of which we shall see further along.

All the essential parts are placed in the interior of the frame and are, consequently, protected against damages caused by a collision, fall, etc.

The gasoline reservoir, M, is located behind the head of the bicycle, and may be filled through the tubulure, m, with a quantity of liquid sufficient for one hundred and twenty miles. The gasoline falls drop by drop into the evaporator, N, in passing through the cock, S, and the funnel, T. Through a simple mechanism, shown in Fig. 4, the gas mixed with air in proper proportions enters the ignition chamber through the valves, O.

A lamp, P, which continually keeps at a red heat a small tube, p, placed above the flame, produces the explosion of the detonating mixture. The piston, I, is thus driven into the cylinder, W, and actuates around the axis, I, the rod, IJ, which is aided in its return motion by a powerful spring, EJ.

As may be seen, the principle is not new, the details of its application alone possessing a real originality. The governing of the motor is, in fact, put at the disposal of the rider, in a very simple and certain manner. To the handle bar, to the right, at the level of



Figs. 4, 5, and 6.—MECHANISM OF THE BICYCLE.

Fig. 4.—Details of the evaporator—partial section: t, funnel for entrance of gas; a, a′, etc., gauze for accelerating evaporation; b, b′, tubes for entrance of the air; c, piston for admitting the mixture into the valve box; d, its rod. Fig. 5.—Details of the distributing mechanism: K″, extremity of the actuating rod; r, t, levers; p, r′, r″, joints; s, spiral spring; w, w′, supports of the spring; n, n′, stop blocks. Fig. 6.—Details of the various valves: v^1, v^2, ignition valves; v^3, suction valve; v^4, v^5, emission valves; v^6, air valve.

the thumb, is fixed a threaded piece, Q, which controls a cord running upon pulleys and connected with the cock that regulates the flow of the gasoline, the valve that admits the gas into the ignition chamber, and, at U, with the valve that allows water to flow from the reservoir, R, for cooling purposes. The opening or closing of these parts can be done gradually by the progressive screwing up or unscrewing of the threaded piece, Q. The rider thus gradually accelerates or slackens the speed of his machine; but a sudden stoppage can also be effected through the freeing of a spring arranged around the regulating piece, and which, allowing it instantaneously to fall to the end of its threading, closes all the communications at the same time.

The most important control given to this handle bar piece is evidently that of the entrance and exit of the evaporator, N (Fig. 4). The latter is thus named because the gasoline falling drop by drop through the funnel, T, evaporates therein. A succession of gauze sieves, a, a′, etc., placed one above another in the cylinder, offers therein the greatest surface of evaporation possible. The external air which, through its mixture with the gas, is to produce the detonating mixture, enters the cylinder through b, and the pipe, b′, through a capsule that prevents the suction of impurities and dust. As for the admission of the mixture into the valve chamber, that is regulated by the piston, c, whose rod, d, as we have above seen, is placed, like the gasoline cock, under the absolute control of the rider. If, then, the latter completely closes the cock, he thus also hermetically closes the admission tube at the same time. The gasoline ceases to fall upon the gauzes, and the mixture to enter the ignition chamber, and conversely.

We have just seen how the production of the mixture is obtained and rendered regular, and it now remains for us to remark how the mechanism of its distribution is made. The ingenious mechanism here employed by Messrs. Wolfmuller and Geisenhof is designed to open the two admission valves at once, at the moment desired, and by the use of a single lever. The cam, K (Figs. 2 and 3), fixed upon the disk wheel, A, and carried along in its revolution, frees, in passing, the roller, K′, mounted upon a guide block that transmits motion to the traction rod, K″. It is this rod that, at V, actuates the distributing mechanism, which it is impossible to represent in Fig. 2, and the principal details of which are shown in Figs. 5 and 6. This mechanism is installed upon a plate that forms a cover for the cooling box of the cylinders. It is constructed as follows: The extremity of the rod, K″, is jointed at r′ with a lever, r, that oscillates around the fixed point, p, and is continuously brought back to its normal position by a powerful spring, S, as soon as the passage of the cam, K, over the roller, K′, has made it lose it.

The extremity of this lever, r, is jointed at r″ to another lever, t, whose extremity commands, at t′, the valves represented in Fig. 6. At about its center, the lever, t (Fig. 5), is jointed again to a crosshead, m, and held upon it with hard friction by two spiral springs. This head engages with the blocks, n and n′, which are provided with corresponding notches. The central part of the lever, t, is thrust alternately against w and w′. On another hand, the levers, t′ (Fig. 6) carry at their extremity another small lever, t″, which controls the valves, v^1 and v^2, leading to the ignition chamber. Owing to this arrangement, the lever, t′, of one of the cylinders causes, at the same time, the ignition in the conjoined cylinder.

If now we suppose that the cam, K, carries along the rod, K″, it will be seen that the lever, t, will recoil and carry with it one of the levers, t′. The crosshead, m, engages at the same time with the block, n, and compresses the spiral spring which is located behind the piece, w. But as soon as the powerful spring, S, acts, its brings the lever, t, to the front and causes the head, m, to engage at n, carrying with it the second lever, tt′, and reciprocally.

This rapid exposé of the general arrangement of the parts of this curious novelty, as the motor bicycle is, will permit our readers to grasp both the high qualities and the minor defects of it. It is certain that the complication of the pieces is here very formidable for a machine designed for a little of every kind of speed and all kinds of roads, but we must also remember that we are as yet witnessing only the first trial of automobile cycling, and we ought to give the inventors a margin of some months. However it be with the criticisms of detail that we might formulate, one fact remains, and that is that the bicycle that we have described is really in operation. Its success in Germany and Switzerland is already so great that the entire product of the manufacturers has been engaged as far as to next May. The patent for France has, it is said, just been purchased at Paris, and it is asserted that by next month we shall see the gasoline motor bicycle enter the Bois de Boulogne.—La Nature.

BEAK LOCOMOTIVES.

Progress always entails progress, and of this we have an excellent proof in the efforts that our locomotive builders are making to increase the rapidity of transportation. They are obliged to do this by anticipation of the high speeds that the electric locomotive will permit of as soon as, having crossed the threshold of troublesome and costly researches, it begins to rush over our renovated railways at a velocity that will perhaps soon become considerable.

It is for this reason that the steam locomotive, which is already so admirably elaborated and so complicated that it seems to realize relative perfection, is at this moment the object of useful improvements. The bogie or swiveled truck in front has given it more elasticity and flexibility. Our engineers are striving likewise, by modifying the external form of locomotives, to reduce to a minimum the great retarding resistance that the wind opposes to the advance of the engine in motion.

In this order of ideas, the Paris-Lyons-Mediterranean Company has once more given an excellent example of initiative in deciding upon the construction of forty locomotives provided with curved cutwind surfaces, and that are called, in allusion to a term used in the United States, beak locomotives. One of these engines, represented in the accompanying figure, has recently been submitted to some very interesting tests that have given good results.

The method of overcoming the resistance of the wind consists in providing the cylindrical and vertical pieces (the smoke stack, firebox, cab, buffer beam and steps) that particularly offer resistance with masks inclined at an angle of 45 degrees with the track.

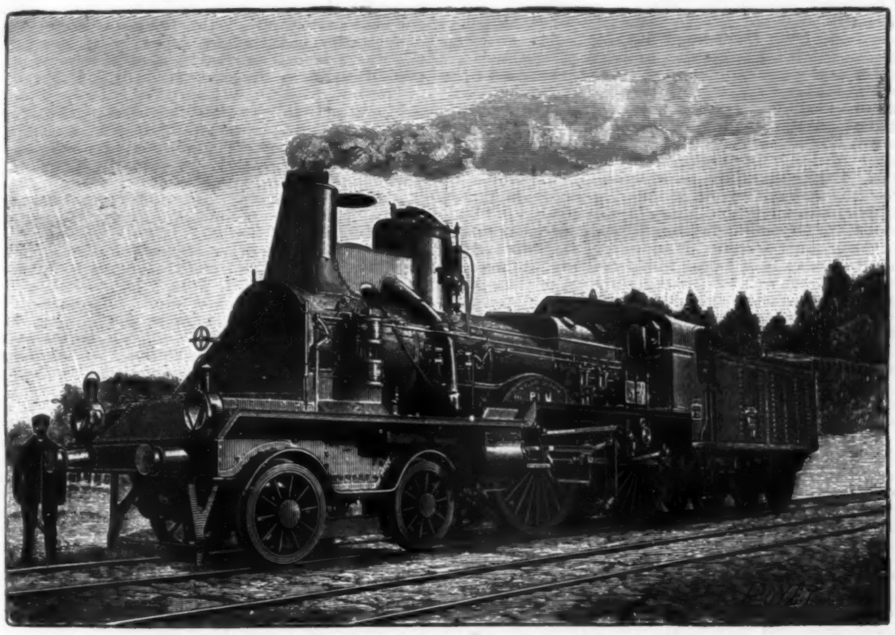
The smoke box also is provided in front with an arrangement in the form of a paraboloid or large plowshare. These arrangements will be further improved after carefully conducted experiments shall have exactly indicated in what direction it is well to carry this system of protection.

The idea of providing locomotives with surfaces of least resistance is not new. The illustrious Stephenson, it appears, thought of it at the outset. In truth, it seems as if this man of genius worked out the entire programme of the most improved locomotives, in their least details, at the first stroke.

Nevertheless, the putting in practice of surfaces of least resistance has been retarded for a long time, and this may well be expained, not by an indifference to progress, but by the fact that the cut-wind arrangement becomes truly advantageous only for the realization of high speeds. It has, therefore, been possible to neglect it for a number of years, but now it has become imperative.

It is well to recall here some experiments that were made in this direction in 1887 by Engineer Ricour, and which defined and determined the evolution that is being accomplished at this moment. Mr. Ricour, in his locomotives, substituted planes inclined in the ratio of three of base to four of height for all the surfaces at right angles with the running direction. Besides, he filled the intervals between the spokes of the wheels with plates of wood, and connected the smoke stack and steam dome by continuous surfaces. Under such circumstances, it was found that the resistance of the air diminished by one half. The result was a notable increase in the effective work, and a saving of about ten per cent. in the consumption of fuel.

In 1890, some analogous experiments were made by Mr. Desdouits, engineer-in-chief of the state railways. An engine was provided with surfaces of least resistance and tried for a prolonged period, making a total run of 180,000 miles. The saving in fuel was from six to eight per cent. and at times reached twelve. It is true that the engineman and fireman were excellent ones. The direct measurement of the resistances, at a speed of 43 miles an hour, and with 120 tons in tow, showed a gain of from nine to ten per cent. Admitting, as an average, a gain of from four to five per cent. resulting from the use of surfaces of least resistance, that is still more than the compound and other systems of locomotives are capable of giving, and a use of which cannot be made without great complications of mechanism and operation.



BEAK LOCOMOTIVE OF THE PARIS-LYONS-MEDITERRANEAN RAILWAY COMPANY.

Mr. Desdouits likewise made an experiment of another kind, which was very curious and worth mentioning. He ran an engine coupled to a train at a speed of 36 miles an hour. In front of it, at a short distance, ran freely another locomotive which masked it. The diminution of resistance noted upon the locomotive of the train under such conditions was 600 pounds.

Cycling, which is so popular at the present time, has furnished data upon the subject of surfaces of least resistance that are not to be neglected. It has been calculated that the cyclist, clad in a fitting suit and bending forward upon his machine in order to diminish the surface presented by his body to the action of the wind, develops, in order to conquer the resistance of the air at a speed of 20 feet per second, a power of 67 foot pounds per second; that is to say, ⅛ horse power. Hence the utility of trainers when they act as a wind cleaver, and hence also the idea that has occurred, but which does not appear to have been carried out in a very practical manner, to provide bicycles with a sort of prow in the form of a plowshare designed to cleave the air. Aluminum appears to be indicated as a material for such prows and for realizing the beak bicycle. We know, in fine, if we consider the case of navigation, that upon giving a vessel a tapering bow instead of a square one, we diminish by four-fifths the stress necessary to haul her.

These various observations and the experiments that we have mentioned allow us to think that the Paris-Lyons-Mediterranean Company will congratulate itself for having put in service its forty beak locomotives that have obtained so just a success as a curiosity. Afterward, for making up the very fast trains that the future has in store for us, it will remain to make use of the long cars of the excellent dining saloon model and of those having a central passageway that are beginning to be seen upon our railroads. Then it will be well to use screens to close the intervals that exist between the cars, and that permit the wind to produce a retarding effect by acting upon the plane surfaces of the cars in the direction of the motion.

These are fundamental modifications that will conduce to an almost complete renovation of the material now in use. While approving of the introduction into these reforms of such compromises as are compatible with the necessities of the exploitation and with those of the amortisement of the materiel, it is to be hoped that they will be accomplished as soon as possible, with the unity of views and persistent research for an improvement that is universally needed.—La Nature.

THE MANUFACTURE OF SALT.*

By THOMAS WARD.

SALT, in one form or another, is perhaps the most widely spread of all minerals. It is a constituent of all sea water, and there are few brooks or rivers that have no traces of it. Salt lakes abound in many districts of the earth, and saline springs are very widely distributed. Salt appears also in the solid or mineral state in beds of rock salt in most of the geological formations, with perhaps the exception of the very earliest. Not only is salt thus widely distributed, but it is also equally widely used, being a necessity of life.

The object of this paper is to deal with the various methods by which salt is manufactured or produced in different parts of the world, but more especially in England.

Brine is the foundation of the salt manufacture, and it will be necessary to define what is meant by it. Brine is water holding salt in various proportions in solution. By salt in this paper is meant chloride of sodium ($Na\,Cl$). Brine exists naturally in the sea, in salt lakes and in some rivers and springs. It is formed also by water coming into contact with mineral salt. Fresh water will take up more or less salt, according to its temperature, varying from 35¼ lb. at freezing point (32° Fah.) to 40 lb. at boiling point (226° Fah.), for every 100 lb. of water. Saturated brine at 60° Fah. contains 26¼ per cent. of salt. Brine is rarely fully saturated, so it is customary to speak of a good brine as 1 part salt, 3 parts water.

This, for practical purposes, is sufficient to remember. In England, especially in Cheshire, the salinometer is graduated in ounces of salt per gallon of brine. The old wine gallon of 231 cubic inches, and not the imperial gallon of 277·274 cubic inches, is the one referred to, and a fully saturated brine is described as a 2 lb. 10 oz. brine. It is a curious fact that the specific gravity of saturated brine is to that of water in exactly the proportion of the imperial gallon to the old wine gallon, or 1·2 to 1.

Natural brines are scarcely ever fully saturated. The water of the sea varies very considerably, containing about 1½ per cent. of sodium chloride in the Black Sea; 2½ per cent. in the North Sea; 2½ to 2¾ per cent. in the Atlantic, and nearly 3 per cent. in the Mediterranean. Where the sea is an open one the salt content rarely exceeds 3 per cent., and varies very little from top to bottom. In salt lakes we meet with brine from less than 1 per cent., as in the Caspian Sea, to more than 10 per cent. of chloride of sodium (to say nothing of the other salts) in the Dead Sea. There are numerous salt lakes on the steppes of Russia; as also in Central Asia, and many other parts of the world. The salt content of these lakes varies according to the season of the year. In the rainy season the brine is weak; in the dry season, saturated. There are in deserts and dry districts, where salt abounds, salty brooks and streams, as the Looni in Rajpootana, in India, and the brooks running into Lake Elton, in the Russian steppes. Natural salt springs, like the seas and salt lakes, are rarely saturated, many being merely brackish; but there are a few where the water contains considerable quantities of salt, as in Cheshire and the Luneberg Heath in Hanover, and when this is the case it indicates the existence of beds of rock salt in the neighborhood. In some parts of the world salt marshes abound, and what are called in America "salt licks," which are of a similar nature. From the sea, salt lakes, salt springs and salt marshes, salt has been at all times obtained, and is so still.

* A paper lately read before the Society of Arts, London.—From the Journal of the Society.

It was a long time before men attempted to find stronger brine than that of the springs flowing away at the surface near brooks and streams. In searching for other minerals, chiefly coal, rock salt has occasionally been discovered, and frequently accompanying it strong brine, often fully saturated. It was not till the year 1670 that rock salt was discovered in England, near Northwich, when prospecting for coal. Brine was found on this rock salt, and was described as more "sharp and vigorous" than that found in the springs rising to the surface, which had been used for making salt from the time of the Romans or earlier. In Canada rock salt was found at a depth of over 1,000 feet in boring for petroleum.

In Germany bore holes have been put down where brine springs of a weak nature existed, and, in the majority of cases, rock salt and strong brine have been discovered. In the United States, within the last few years, many bore holes have been put down, in some cases to the depth of 2,500 feet, and rock salt discovered, but no natural brine. The same has been the case at Fleetwood and Middlesborough in England. In all these places water has been put down the bore holes, or permitted to enter from the water-bearing strata passed through, and allowed to saturate itself on the salt, and is then pumped up. This system of obtaining brine has been used in Germany and the east of France for many years. Rock salt being very easily soluble, the water quickly becomes saturated. The plan usually followed is to have a double pipe or tube, that is a small pipe or tube within another rather larger. The larger tube is usually five inches in diameter, the smaller about 3½ inches in both England and America. The ring, or space between the two pipes, is used to put the water down, while the internal pipe serves as a pump up which the brine rises. A column of 120 feet of water balances one of 100 feet of saturated brine. Occasionally, in America, the water is forced down at a pressure of 160 lb. or so to the square inch, which pressure forces the brine up the inner pipe to the surface, and no pump is needed.

At Tully, in New York State, some 15 miles or so from Syracuse (one of the oldest salt manufacturing districts in the United States, and where only weak brine existed), a bed of rock salt has been discovered at a spot some 400 feet above the level of the salt works at Syracuse. About 400 feet higher still, and further up the valley, several lakes exist. The water of these lakes is conveyed by pipes to the beds of rock salt at Tully, which are some 1,800 feet below the surface, and the head of water is sufficient to lift the brine to the reservoirs on the surface, whence it flows by gravitation to the alkali works at Syracuse. The system of making bore holes and allowing water to get to the salt has extended very rapidly.

In the Northwich salt districts, in Cheshire, there are a large number of abandoned rock salt mines. Fresh water has broken into these, and saturating itself from the rock salt, has formed enormous underground reservoirs containing a practically inexhaustible supply of strong brine.

The brines formed immediately on or in the rock salt are nearly or quite saturated, and therefore much stronger than the natural brines found in seas, lakes and springs. In the Carrickfergus district in Ireland, where there is no brine on the rock salt, and where no water is put down bore holes, the rock salt is mined and put into reservoirs, and the water added to it.

Rock salt has been used to strengthen weak brines, or to mix with and strengthen sea water, for a considerable time. There are salt works along the coasts of Ireland and Scotland at the present time, where the brine is formed in this way; and in Belgium, Holland, and Denmark, large quantities of rock salt are imported for dissolving and making brine, which is then used in the manufacture of white salt.

Brine is present in all parts of the earth, and of all degrees of strength up to saturation point. Until it reaches this latter point, however, no salt will form; hence it is evident that such a thing as a salt deposit at the bottom of the sea is impossible, sea water containing, on the average, only 3 per cent. of salt. When it is said that the huge beds of rock salt, met with in so many places, were deposited at the bottom of the sea, it is evident that the statement is incorrect, or else that the sea water must have been a saturated brine. This, however, could not be; for animal and vegetable life cannot exist in a fully saturated brine. When brine is of full strength a state of equilibrium is reached, and any decrease in the quantity of water or increase in the quantity of salt destroys this equilibrium, and a portion of salt is deposited. The water once saturated will take up no more salt, and it is a common saying in the salt districts, that the safest way to keep rock salt from dissolving is to put it into saturated brine.

Salt, in brine, is not held in suspension, but in solution. Hence, however long the brine is allowed to remain, say in a closed vessel, no salt will deposit. The business of the salt manufacturer is to remove the water, when the salt will crystallize out and form a deposit. During the whole time of the removal of the water the salt deposits in such quantity as to keep the brine just saturated. The best, and almost only way, to get rid of the water is by evaporation.

The problem to be solved in the manufacture of salt is to so regulate the evaporation that the kind of salt required is produced. The great factors in evaporation are heat and dryness. A moist heat is almost useless, hence, in tropical countries where there is great moisture, little or no salt can be made. A dry wind, without much heat, causes rapid evaporation, and in Germany, where the natural brines are very weak, huge thorn hedges are built up in the line of the prevailing dry winds, and the weak brine is allowed to trickle among the thorns so exposed, and a large portion of the water is evaporated. The brine caught at the bottom in troughs is in this way much strengthened. This graduating of the brine, as it is called, is frequently resorted to.

In rock salt mines, where the air is dry, and neither sun nor wind can penetrate, evaporation takes place, and when brine has flooded the sole or floor of the mine, as has happened occasionally, the water, in process of time, becomes evaporated, and splendid crystals of rock salt are left behind.

There is another way in which salt is sometimes produced in intensely cold regions, viz., by making shallow reservoirs, and allowing the watery portion of the brine to freeze, and the salt to deposit. A short time since a patent was submitted to me for artificially freezing brine, and thus obtaining salt. The great drawback to any such system of salt making is, that there will always be three tons of ice produced for every ton of salt made. Besides this, it would not be possible to manufacture the different qualities of salt required. Practically, the evaporation in making salt is caused by heat, and the water evaporated dissipates itself in the atmosphere in the form of steam or vapor and requires no further attention.

The heat used in salt making is either natural or artificial. Natural heat is that of the sun. All salt made by the heat of the sun is technically known as solar salt. Solar heat is the cheapest obtainable; but it has its drawbacks. The greatest of these is that it cannot be regulated; consequently it is not possible to make the various grades of salt required, which all need different degrees of heat properly regulated. Another drawback is that the heat is not continuous. After the sun is set the evaporation is very slow, and the time required to make salt is much lengthened, and in the rainy season or winter no salt can be made. Again, if the air is very moist or rain falls, not only is there no evaporation, but a good deal of the work previously done is undone. Part of the water evaporated returns, and to restore the brine to saturation some of the salt already made is dissolved, the water saturating itself at the expense of the crystals already formed. At Syracuse, in New York State, and also in Michigan, men are constantly on the look-out to run wooden covers over the pans in which solar salt is making, as soon as any sign of rain appears. Solar salt making can only be carried on successfully where the summers are hot, and at the same time fairly dry. It has often happened that a spell of wet weather has set in before the salt harvest has been gathered, and has blighted the prospects of the salt makers. Where, as along the shores of the Mediterranean, and along the Atlantic shores of Spain, Portugal and France, the seasons are regular, and fine weather is tolerably sure, much solar salt is made. The shores of the Red Sea and Indian Ocean are in many places suitable for solar salt making. The numerous salt lakes on the Russian steppes produce immense quantities of solar salt, as also does Lake Sambhur, in Central India. In the Dead Sea and along the eastern shores of the Caspian Sea, where there are both heat and dryness, salt is deposited very largely, and huge beds of rock salt are being formed. From these modern deposits the method of formation of rock salt in past geologic ages can be easily determined.

In places where solar heat cannot be relied on in the manufacture of salt, or where qualities of salt are required that the heat of the sun will not produce, artificial heat is used. In early days we are told that the brine was sprinkled over burning wood, and the salt collected from the ashes. Wood has at all times been used as a fuel for obtaining the heat for evaporating brine. In England, until comparatively recent times, it was almost exclusively used. In a letter of February, 1605, it is said that the wood consumed annually in making salt was, at Nantwich, of the value of £1,728; at Middlewich, £1,435 4s.; at Northwich, £2,056 10s.; or as the letter says, "Spent in the wich houses yearly in wood, £5,219 14s." Wich house was the name for the house in which the pans were kept for boiling the salt. The word is still frequently used at Northwich for the pan house. The pans at this period were called "leads," being made of lead. Wood is still used on the Continent, where coal is scarce, for boiling the brine, and it is used either by itself or in conjunction with coal in Canada for the same purpose. In the lumber districts of Michigan the refuse wood and sawdust from the saw mills are used under the boilers to generate the heat for the steam required in making salt.

Slack, or small coal, is almost exclusively used in England, and most parts of the world; being more plentiful and much cheaper than wood. The average price of this fuel at the salt works in England is from 5s. to 6s. per ton. In England, direct heat is chiefly used; that is, the fires are made underneath the pans of vessels containing the brine. In America and Canada the heat is first used to generate steam in large boilers. This steam is conveyed in pipes to the pans in which the salt is made, and the pipes pass through the brine, communicating their heat, and causing evaporation. The chief business of the salt manufacturer is to utilize to the best purpose, for the production of salt, the heat obtained from the fuel. To this end innumerable patents have been taken out, but few have been so successful as the simple application of direct heat to open pans. The method seems a very primitive one, and most visitors to salt works think they can improve upon what they consider a rude, antiquated system. I have brought before me, and have seen working, scores of patented plans. In all, or nearly all, the idea was to economize heat; and if the whole of salt manufacturing consisted in evaporating the greatest quantity of water with the least quantity of fuel, doubtless many of the schemes would succeed instead of failing, as they do now. The majority of the plans are schemes for generating steam and using the heat, but occasionally (as just recently) gas under pressure, mixed with air, is lighted under a small kind of diving bell, and all the heat thus generated is communicated to the brine in which the heater is immersed. Perhaps the most successful method of utilizing heat is by what is called the vacuum process. In this, again, steam is generated in a boiler, and used to cause evaporation in a closed vessel. Thus, roughly speaking, salt manufacturers employ either direct heat from the furnaces or steam generated in a boiler and conveyed through pipes.

Before describing more at large the methods used for producing the various kinds of salt, it may be well to recall the composition of brine.

In sea water, and the water of salt lakes and of most brine springs, the proportion of salt is comparatively small, and that of water very large. Hence, before any salt can be made, the water must be reduced so as to leave the proportion of 76 water to 24 salt; or, as before stated, 3 parts water to 1 part salt. To evaporate this water requires a great amount of heat, and it will at once be seen that if the heat obtainable is small, it must be applied for a long time. In artificial brines, or such natural ones as are found on beds of rock salt, the proportion of water to salt is usually 3 to 1 to commence with; so that it does not take long before there is sufficient evaporation to cause the salt to form or crystallize out of the brine. Brine boils at 226° Fah., but it is not necessary to heat it to this point before evaporation commences and salt forms. The whole business of salt making consists, as was said before, in using the proper amount of heat to produce the kind of salt wanted. The greater the heat, the more rapid the evaporation and the finer the grain of the salt. The lesser the heat, the slower the evaporation and the coarser the grain of the salt. The fine or boiled salt is taken frequently out of the pan, the coarse less frequently, according to the degree of coarseness wanted.

With varying exceptions, adapted to suit different localities, the method used in making solar salt on the sea shore is to allow a quantity of sea water to run into a reservoir or pit, at the top of the tide. From this reservoir the brine is conducted to a series of shallow pits or pans, having a considerable area but little depth; the object being to expose as great a surface as possible to the heat of the sun. The shallowness allows the brine to soon become heated, and evaporation to commence. There is a series of these shallow pans or basins, and the brine, as it becomes stronger by the evaporation of the water, is passed on from one to another, till in the last, being fully saturated, the salt begins to form.

As the heat of the sun obtainable is small compared with fire heat, the process of evaporation is slow, and the salt formed coarse in the grain. This salt is "harvested" at considerable intervals, and only during the hot, dry season. At Syracuse, in New York State, and at Zilwaukee on the Saginaw River, in Michigan, solar salt is made from the brine of the districts. In Syracuse, where the brine is weak, it is first run upon a "flat" or wooden floor with a slight rim round it, only allowing a layer of very shallow brine to lie upon it. When strengthened, this brine is passed to a series of shallow wooden pans about 18 feet by 16, and 4 to 5 inches deep, of which there are many thousands constantly in use. The salt is taken out or "harvested" as it is called twice in the year.

The salt obtained from the Salt Lakes on the Russian steppes, and from Lake Sambhur, in India, as well as from other salt lakes in various parts of the world, is only got in the dry, hot season. At this season of the year the lakes shrink very much in area, and the salt forms in the shallow pools left behind by the receding lake, and in the shallow portions of the lake itself. The salt is taken from the bottom of the pools, or shallow portions of the lake, and stacked on the shores. Lake Sambhur in the wet season is from 15 to 20 miles in length; but in the dry season not more than from 3 to 4 miles.

One of the most interesting deposits of solar salt is that in the Kara Boghaz Gulf, on the east coast of the Caspian Sea. This large gulf, covering an area of more than 2,000 square miles (German), is connected with the Caspian Sea by a narrow entrance about 150 yards wide and 5 feet deep. There is a bar at the mouth of this entrance over which there is a constant flow of Caspian Sea water at the rate of 3 miles per hour, containing slightly less than 1 per cent. of salt. So great is the evaporation over this extensive body of water that it is estimated by the best authorities that at least 350,000 tons of salt are being deposited daily, and an enormous bed of rock salt is being formed on the bottom of the gulf. This is one of the most instructive salt deposits in the world, and shows how, by continuous evaporation, even so weak a brine as 1 per cent. can be made to deposit its salt.

The vessels, if they may be so described, in which solar salt is made are natural basins, such as lagoons and salt lakes, or ponds and pits made along the sea shores. The earliest artificial vessels used in evaporating brine were very small. As the demand for salt increased, the size of the vessel increased in a corresponding ratio, till now pans of enormous size are in daily use. The first pans of which we have any record in this country were made of lead, and were very small. There are two in the Salt Museum at Northwich, which were discovered a few years ago. The smallest is, roughly, 2 feet 1 inch square by 3 inches deep, and holds about 7 gallons. The other is 3 feet 8 inches by 2 feet 8 inches, and 4 inches deep, holding about 20 gallons. This latter pan is about the size used in the sixteenth century, and six of these leads, as as they were called, were included in each wich house. In Hall's "History of Nantwich," p. 203, we have the following interesting description: "The ancient way of makeing salt with us was in lead pans, whereof every wich house had six of equal gage: and in those they boyled their salt with wood cloven and fitted for ye purpose. This was ye way and usage of makeing salt in this towne till the VIth yeare of King Charles I. (1632). And then it was, that some fancifull persons thought it would be more for their profit to boil their salt in iron pannes (of equall gage with the six leads) with pitte coale, pretending that wood grew scarce."

Thus, at the time that iron was substituted for lead, coal took the place of wood. In 1650 we find a great dispute caused by the substitution of two "great pans," instead of the previous four or six. In 1675, it would seem the large pans were in general use, as in a report made in that year it is said, "Eache wich house hath two ovens, a ship, a chamber, or store, and two iron pannes." By a "ship" is meant a long wooden trough, generally a tree trunk hewn out, to contain a store of brine.

Shortly after the proper way of using iron for the making of salt pans was found out, the size of the pans began to increase rapidly. In 1748 Dr. Brownrigg, in his book on "The Art of Making Common Salt," says, "The length of some of these pans is 15 feet, the breadth 12 feet, and the depth 16 inches." In a note he adds, "At many works they use pans of a much less size than here described. But those used at Shields and other places near Newcastle are much larger, being commonly 21 feet long, 12½ feet broad, and 14 inches deep, being the largest salt pans used anywhere in Great Britain." According to a small pamphlet published at Leipsic, in 1776, by a German named Chrysel, who had been in England experimenting at the salt works, the largest pans in the country then were two at Northwich, being respectively 36 feet by 25 feet and 13 inches deep, and 40 feet by 27 feet and 13 inches deep, and one giant at Winsford 52 feet by 26 feet and 13 inches deep. The average pan at that time is described as 24 feet by 15 feet and 12 inches deep. At the same time Chrysel speaks of the German salt pan being 8 feet square by 9 inches deep. Little by little the size of the pan grew, more especially the length of it; the width being determined chiefly by the length of the raker the man taking or drawing the salt out of the pan could comfortably use. From 1694 to 1823, salt paid a heavy duty, so that the manufacture did not grow so rapidly as after 1823, when the duty was repealed. During the great French war this duty was as high as £30 per ton.

The pans used at the present day are very large. Those actually working in Cheshire and Worcestershire range from 30 feet by 24 feet and 15 inches deep (this being about the smallest now used except in a few of the oldest works, where pans about the size of those in use a century ago still remain) to 130 feet by 25 feet and about 18 inches in depth. The usual size for pans that are required to boil is from 30 feet to 40 feet in length, and from 20 feet to 27 feet in breadth. For pans making coarse salts, the usual size is from 60 feet to 70 feet in length by the usual 25 feet to 26 feet in width, though at many of the modern works these pans are from 70 feet to 130 feet in length, and up to as much as 30 feet, or, in one or two cases, 32 feet in breadth. The most approved width is about 26 feet.

There is no absolute rule for size of pans. There are pans, under which exhaust steam is used, as much as 150 feet in length. Should it be found necessary to use a long pan for boiling purposes it is "mid-feathered" off, as it is called; that is, a portion is divided off by a wooden partition, making a "front pan" for boiling and a "back pan" for coarse salt.

The pans spoken of, so far, are all open pans, and the heat is given to them by fires underneath. Besides these open pans there are a number of circular inclosed pans, known technically as "patent butter pans," from the kind of salt made in them. This salt is the finest made in England. The pans are from about 21 feet to 27 feet in diameter, and are completely covered in. The fires are made under these pans as under the open ones, and the waste heat from the fires and steam from the pans are conveyed under other open pans, where coarse salt is made; or else the waste heat is carried in flues to the stove, where the salt made in lumps, or squares as they are called, is dried.

The growth of the pans from the one holding seven gallons, or the average one of 20 gallons, to that in use now containing 30,000 gallons, is comparable to the growth of the trade. In 1675 the three Cheshire "wyches" are stated to have produced 20,000 tons of salt annually. In 1875, when the large pans were in extensive use, the same district produced about 1,750,000 tons.

The pans in use in America differ very considerably, with few exceptions, from those in use in this country. In Syracuse, New York State, and Zilwaukee, in Michigan, "covers" are used when solar salt is made. In Syracuse, Warsaw, Saltville, in Virginia, and at a few small works in other parts of the country, "kettles" are used. These are very similar in appearance to the ordinary washing boiler found in cottages in this country. These kettles are set in a double row, sometimes to the number of 100, and the flues go underneath. In several cases, instead of the kettles being set directly over the flues, they are set in what are called "jackets," and steam is forced into this "jacket" or steam chamber. The pans, however, in most common use are called "grainers." These are made of wood, the general size being about 120 feet by 11 feet, and 22 inches deep, though some are as long as 190 feet. Lying near the bottom of these grainers are iron pipes, about four inches in diameter, which pass up and down the pans, and through which live steam is passed. In the lumber districts, however, the exhaust steam from the saw mill boilers is used to heat the brine. In the St. Clair district, Michigan, and the Kansas salt districts, iron pans, similar to those in England, are being generally adopted. At St. Clair a circular pan—similar to the patent butter pan in use in England—was being worked four years ago. At Silver Springs, in New York State, and, more recently, at Cayuga, in the same State, and also at several places in Michigan, vacuum pans are being used. These pans are the most successful patent pans now being worked. They consist, generally, of a cylindrical vessel, containing a set of pipes. The brine to be evaporated is either contained in the pipes, and the chamber heated by steam, or the chamber contains the brine, and the pipes the steam, which is used direct from the boiler. As fast as the steam produced by evaporation rises, it is carried away by a powerful air pump and a vacuum kept. Evaporation is by this means rapid, and the salt forms very quickly. It is proposed to use the steam thus drawn off to heat another similar vessel, and in some cases a third. The vacuum pan has its advantages, but brine is difficult to deal with, and the pipes get coated with sulphate of lime and rendered almost inoperative.

In many places it is customary to heat the brine before passing it into the evaporating pans. Most frequently this is done by waste or exhaust steam, or the pipes through which the cold brine passes are carried at the back of the fires or along the flues. Occasionally the brine heaters are placed at the back of the pan, and between it and the chimney, so as to still further utilize the heat.

In England the pans are made of either iron or steel plates, riveted together. The usual thickness of the plate is ¼ inch for steel and ⅜ for iron, with ½ inch or ⅜ for the rims. The sizes of plates vary very much, from about 3 feet to 8 feet in length, and from 1 foot to 4 feet in breadth. The pans are heated by fires made under them. These vary from 2 to 4, according to the width of the pan. The usual number is 3 for 24 feet, though many 25 and 26 feet pans have 4 fires. The fire grate is about 5 feet in length, and has fire bars from 4 feet to 4 feet 6 inches, and a dead plate, as it is called, in front of them. The distance of the fire bars from the pan bottom is usually from 2½ to 3 feet, though in special cases more. The heat from the fires passes under the pan along flues to the chimney.

There are many systems of arranging these flues, but the object in all cases is to economize heat by

making all possible use of it under the pan, and not letting it escape too soon up the chimney. It is impossible to utilize all the heat, for the draught up the chimney, which is necessary to make the fires burn briskly enough to sufficiently heat the brine, carries much heat with it.

In the case of the short pans, where the brine is required to boil, so that salt suitable to form the squares or lump salt of commerce may be made, the surplus heat, not used in making salt, is passed through flues and utilized in the stove or drying room at the rear of the pan.

It is not necessary to enter into all the details of construction of the pans or the hurdles upon which the salt is placed when taken out of the pans or the pan houses, or other common arrangements; it will be more interesting to describe how the numerous salts of commerce are produced and fitted for the purposes for which they are used.

From what has been previously said, it will have been seen that the whole process consists in the right manipulation of the heat employed. To produce very fine salts the brine must boil, which it does at 226° Fah. The coarsest salt does not require more than about 90° Fah., and between these ranges the various kinds of salt are produced.

The grades of salt manufactured in this country may be classed under the heads of either (a) fine salt or (b) coarse salt. The fine salts are such as require the brine to boil, and are technically known as butter salts and stoved salts. The butter salt is divided into patent butter, fine butter and coarse butter. The stoved salts are usually known as handed squares and factory filled squares or lumps. There is no difference in the quality of the salt in butter and stoved salt. Both kinds are boiled salts, but the butter salt is drawn out of the pan in bulk and allowed to drain, then taken into a storehouse and stored in bulk. The stoved salt is drawn out and placed in moulds or tubs, as they are called; then, after draining, it is turned out of the tubs and carried into a hothouse or stove to be thoroughly dried. The coarse salts are known as common salt and fishery salt, and there are varying grades of both. Common is chiefly known as either fine common or coarse common. Fishery salt is usually classed as second fishery, best fishery, or best Scotch and extra fishery, described as either X or XX. There is a kind of salt coarser still, known as bay salt. These classes include really all the salts of commerce. There are special grades made for special purposes, or to meet special fashions, that have particular names given to them, such as cheese salt, brisk salt, middle grain, marine, Boston common, light Lagos, special coarse, besides numerous brands of factory filled salts, having particular names, as well as many kinds of table salt, sold under all sorts of names and descriptions.

The pans are worked by men known as firemen and wallers. The men drawing the salt into moulds very often combine both the fireman and the waller in themselves, and are generally known as lumpmen and salt boilers. The business of the fireman is to "put the salt into the pan," as it is termed. He is indeed the real maker of the salt, and it is his business to attend to the fires and see that the proper degree of heat is maintained to produce the salt required He has a damper placed in the flue near the chimney to regulate the heat. The regulation of the heat is almost entirely a "rule-of-thumb" question. It is very rare, indeed, that a thermometer is used. The technical knowledge acquired enables the man to see at a glance whether the pan is working properly; and the quantity and quality of the salt produced show whether he has done his duty. Besides attending to the fires, it is part of the fireman's duty to "rake off," as it is called, that is, to rake the salt back that falls over the fires, so as to prevent the plates burning. In some cases he has to rake the salt from the middle of the pan to the sides. He has also to see that the pan is kept properly supplied with brine, which is usually allowed to flow gently into the pans during the making of the salt. The whole of the brine is never evaporated, or the salt would be difficult to draw out, and would often be completely discolored and spoiled.

The man whose duty it is to draw the salt out of the pan is called a waller, from an old Saxon name meaning a boiler. In early times, when the pans or leads were small, one man boiled the salt and drew it out of the pan. When pans increased in size, the waller got an assistant to help in the firing and to wheel the ashes away. Now, in many cases, the fireman and the waller are entirely distinct. The fireman having put a proper quantity of salt into the pan, the waller proceeds to lift or draw the salt out, using a peculiar bent perforated shovel called a skimmer. His only other tool is a raker, either with a long or short handle, to bring the salt near enough to the side of the pan to be lifted out. As the brine is not all evaporated, the salt in being lifted through it is washed, and much of the brine runs back into the pan through the perforations in the skimmer. All salts, except such as are put into moulds to be stoved, are thrown on a flat floor or hurdle, sometimes raised as high as the rim of the pan, so as to allow the brine draining from the salt to run back into the pan. Where, however, brine is plentiful, the hurdle is level with the "standing side" or place where the waller stands to draw the salt. After the salt has remained some hours on the hurdles, for the bulk of the brine to drain out of it, the waller fills it into carts and wheels it to the storehouse. The quantity of salt drawn out of a pan depends upon the size of the pan and the length of time the salt remains in the pan, and varies from five to eight tons per day in the case of handed squares or factory filled squares. Where pans are drawn once a day the quantity of salt varies from seven to ten tons or more; where every two days, these quantities are doubled. Fishery pans, drawn every seven, ten or fourteen days, usually have from twenty-five to thirty-five tons of salt in them.

The brine from which the salt is made in Cheshire and Worcestershire is found just overlying beds of rock salt. It is simply the ordinary spring or well water of the district that has come into contact with the salt beds, and has thus become nearly or quite saturated with salt. A shaft or well is sunk to this brine and it is pumped up and conveyed to large reservoirs made either in the earth or made of wood. From these reservoirs the brine runs through iron pipes (though perforated tree trunks were formerly used) to the pans.

The brine as pumped from the earth is generally as perfectly clear as the purest spring water. When thus pumped up it may, however, be either weak, that is, not fully saturated, or may contain impurities. Brine is rarely if ever a solution of pure chloride of sodium and water; and often requires a certain amount of treatment either before or during the manufacture. When the brine is merely weak it is a simple question as to the cost of the fuel necessary to evaporate the water, whether it will pay to make salt out of it or not. The chief impurities in solution are sulphate of lime, chloride of calcium and chloride of magnesium. There are, at times, impurities in suspension, such as marl, or clay, but these can be allowed to settle in settling tanks or to be filtered out. Occasionally a gelatinous mixture, chiefly jelly from calves' feet, made into a broth, is used. This is put into the brine, and as the brine heats a scum forms on the top which is taken off. The impurities in solution are more difficult to deal with. The sulphate of lime deposits at a less heat than the chloride of sodium, and forms a scale on the bottom of the pans. A portion of salt deposits on the lime, and the whole forms a hard crust of salt and sulphate of lime, known as pan scale. Over the fires, where the salt that falls is continually raked back, only a very thin lime scale forms, which is very hard and almost insoluble in water. Every brine contains more or less of sulphate of lime. It is this sulphate of lime that interferes so materially with the vacuum pan process, and many other patented processes that might otherwise succeed. It is necessary, where the lime is in excess, to scale or pick the pans very frequently. Boiling pans scale much more freely than the pans used in making coarse salts, and require letting out at intervals of two or three weeks to be scaled or "picked," as it is called.

The chlorides of calcium and magnesium are only present in small, almost inappreciable, quantities, in English brines; but in the American brines, especially in the older salt districts, they are present to a serious extent. Where these chlorides are in excess the salt very readily imbibes moisture, and, at the same time, it is nearly useless for curing purposes.

It is usual to treat the American brines with quicklime in the reservoirs, and this is allowed to gradually settle, so that some time must elapse before the brine can be used. Hence numerous small tanks or reservoirs are required. Where kettles are used flat sheets of iron are suspended in them, and as the brine heats the objectionable ingredients, to a considerable extent, deposit on these plates, which are then removed. Where, as in pans or grainers, this cannot be done, the salt is often washed in a solution of saturated brine and soda, which removes the chlorides. Brine is very easily affected by various ingredients, and small quantities of soap, glue, resin and similar things are used for various purposes difficult to explain. This is called, technically, "poisoning" the brine. The grain of the salt is chiefly affected by these things. A small fragment of butter will change the working of a pan, and a very small quantity of several very simple, but very mischievous, materials will entirely alter the working of the brine and change the quality of the salt. It is the knowledge of these various apparently trifling things that distinguishes the old salt maker from the novice; and the lack of this knowledge that renders so many patents useless.

The natural salt crystal, when heat is used to evaporate, and the crystals form on the surface of the brine, as is usually the case, is in the shape of a hollow, inverted pyramid, technically known as a "hopper." This hopper only forms when coarse salts are being made, and the surface of the brine is quite still. The hoppers float on the surface and keep increasing in size and thickness until they will no longer float. They then sink to the bottom of the pan, and if allowed to remain become solid and lose their regular shape by others falling on them and forming an irregular mass. In boiled salts the crystals which first appear on the surface of the brine are broken by the motion caused by boiling and do not form hoppers visible to the eye, but sink quickly to the bottom as minute flakes or grains.

The crystal of rock salt is a perfect cube, with a line of cleavage parallel with each face of the cube. This crystal is of very slow growth, and forms at the bottom of the brine when the evaporation is very slight. Rock salt crystals are semi-transparent.

The following will give an idea of the processes pursued in salt making:

Patent Butter Salt.—This salt has the finest grain of any salt manufactured. The pan used is circular and covered over, and the brine is kept boiling. There are sets of rakers kept moving by machinery, so that the salt, owing to the constant motion of the brine, does not crystallize except in very small grains, and these are carried by the rakers into the pocket at the side. There are two sets of men employed at these pans, as they are constantly at work, and the salt is removed twice every twelve hours.

Fine and Coarse Butter.—These qualities of salt are made in open boiling pans, and the fine butter approaches very near in grain to the patent butter, but is only taken once in twelve hours out of the pan. The pans used for butter salt are shorter than those used for the coarser salts. There is a gradual merging of butter salts into common salts, so much so that it is difficult to tell whether to call some qualities coarse butter salts or fine common salts. The coarse butter salts do not require the brine to be kept constantly boiling.

Common Salt.—This salt, which is the next in coarseness to butter salt, is made at various temperatures, but generally from 170° Fah. to 190° Fah. Common salt, called in some districts broad, is the most cheaply made of any salt. The pans are very long, and there is a greater utilization of the heat under them than under any of the pans where the brine is boiled, and, consequently, more salt is made per ton of fuel consumed. It is usual to consider two tons of common salt made for each ton of fuel used as satisfactory. This is about the average, though it varies with the quality of the fuel. As much as two and a quarter tons of salt per ton of fuel is at times produced. It must be understood that saturated brine is used, or these results could not be obtained. Common salt is the salt used at the alkali and other chemical works; also at soap works, glass works, and a variety of other works. It is used also, under the name of broad salt or agricultural salt, for land. (Sometimes by agricultural salt is understood refuse salt or soiled salt of any kind.) Common salt is taken out of the pan every twenty-four hours, if it is to be required to be fine, but only once in two days for the ordinary or coarser kind, and every three days for the special coarse.

Fishery Salt.—This salt—which obtains its name because of its extensive use for curing fish—is a coarse solid grained salt. Fishery salt approaches most nearly to solar salt. The degree of heat necessary to produce this salt is less than that required for common salt, and the salt is allowed to remain longer in the pan, so that the salt crystals can grow and "feed," as it is called. Some brines are more favorable for making fishery salt than others, though it seems difficult to say why this is so. The chemical composition of the different brines is so similar that only by practice can it be known which brines are most suitable for any particular class of salt. A few pounds of alum put into a pan of brine cause the crystals of salt to form of a harder and more solid kind. For what is called second fishery, which is the most extensively used, the salt remains in the pan seven days. This is the usual time, though with a few brines four or five days will suffice, while with others ten days will scarcely be enough. Best fishery, or best Scotch fishery, as it is called, is coarser and solider in the grain, and remains 14 or more days in the pan. When the salt has been so long in the pan, a portion of it near the fires is much coarser than the rest, and this forms the extra fishery or X and XX.

Bay Salt, of which very little is specially made, is the coarsest salt manufactured. Before any brine is put into the pan, thorns are laid all over the bottom of the middle portion of the pan, and strings are stretched across from side to side, a few inches apart; the brine is then put into the pan, and the fires made hot enough to nearly boil the brine. As soon as this point is reached, the fires are raked out, and the brine allowed to quickly cool down. In this process of quick cooling, the crystals of salt form in cubes all over the strings and thorns. Brine, when nearly boiling, will contain more salt than when cold, so that the sudden cooling causes the salt to rapidly crystallize out. When the crystals have "set" on the thorns and strings, small fires are put again under the pans and kept up continuously for about a month. The salt is then drawn out and the crystals taken from the thorns and strings. Besides these there are crystals on the sides of the pans. After draining, the large crystals are picked out by hand and the remainder of the salt is passed through riddles, and the coarse crystals all put into a warm room to dry or be stoved. It is a very pretty sight to see a pan with the strings and thorns all covered with crystals. In making bay salt and best fishery salt there is always a considerable quantity of inferior grained salt, especially at the back end of the pan, caused by the flaky, small grained salt formed on the surface being carried back by the circulation of the brine from over the fires to the back or cooler end of the pan.

Handed Squares Stoved, or lump salt, such as is carried about in hawkers' carts for sale, and is used largely for household purposes, is the same quality as fine butter salt. The name butter was given to the salt because of its extensive use in butter making. Instead of the waller drawing out the salt in a large heap on the hurdles, he puts it into tubs which stand inside the pan, generally on a little platform at the side. These tubs are of various sizes, and are known by the number of lumps that make a ton of salt. The most common sizes for home use are one hundred and sixties, one hundred and twenties, and one hundreds. The larger size, or eighties, are generally shipped coastwise. The waller proceeds to fill the tubs that he has placed inside his pan, and, as he fills them and the bulk of the brine has drained out, he lifts them out upon the hurdle to still further drain. After an hour or so the lumps are turned out of the tubs, and, being "happed," or patted, into proper shape, are carried into the hot house, where they are allowed to remain till thoroughly dried through. The temperature of the stove varies very much, but is generally about 130° to 140° Fah. When a lump is thoroughly dried, it will "ring" when struck. Unless a lump is thoroughly dried, it will break or go soft when in transit in the boats or vans. It is necessary that the squares or lumps made for sale should be of fine salt, as the finer the salt the harder it sets and the less easily is it broken. Only about one and a half tons of squares are made per ton of fuel used, much heat being required in the stove to dry the salt.

Factory Filled Stoved Lumps.—In some trades it is necessary to have stoved salt, but squares or lumps would be very inconvenient. When this is so, the lumps, after drying in the stove, are taken to a mill and broken and filled into sacks or bags. For the finer qualities of salt sieves are used in connection with the mill, and all degrees of fineness, from ordinary butter salt to superfine table salt, are produced. The trade in what is called packet salt is extending. Instead of the large lumps, which are apt to get dirty and soft, small calico bags, holding 12 lb., 7 lb., 5 lb. and 3 lb., are much used, especially in America. In England, jars, bottles, drums and paper packets are much used, and the penny packet, or even halfpenny packet, is coming into vogue. The salt in all these packages is a stoved salt, which has been milled and sieved. In America there is a general absence of stoves or drying rooms, and no moulds are used. The general use of grainers and steam leads to the production of what is known as common fine salt, a kind of coarse butter salt. As practically all the heat in the steam is used in making salt, none is left for stoves. To meet this difficulty, what are called "Hersey Driers" are used. These are iron cylinders, similar to an ordinary land boiler, of some 30 to 36 feet in length. They are set at an angle over a furnace, or have a jacket for steam. The salt, after being drawn from the pan and allowed to drain, is passed into the upper end of the drier, and as this latter revolves, the salt passes slowly over the heated surface till it reaches the lower end of the drier, where it is discharged perfectly dry and very hot. If a finer grade of salt is wanted, it is passed through small mills, and thence conveyed to the packing rooms, where it is filled by girls or young women into the various packages before described, and usually these are stowed in barrels, which in America take the place of sacks in this country.

It would take too long to describe the trade in salt

at home and abroad. The magnitude of it can, however, be conceived when the last government return for 1893 gives the following figures for the United Kingdom: Rock salt, 192,960 tons; salt from brine, 1,731,069 tons, or a total of 1,924,029 tons. The year 1893 was less than 1892 by some 34,000 tons.

The salt districts of England where white salt from brine is produced are Cheshire, where in 1893 1,213,362 tons were produced; Worcestershire, which produced 192,021 tons; Middlesborough district, 289,198 tons; Fleetwood, 37,488 tons. In Cheshire the trade has been carried on from the earliest times, and is now connected with Winsford, Northwich, Middlewich and Sandbach. In Worcestershire the manufacture has existed for centuries, at Droitwich, but of late Stoke Prior has produced most. Middlesborough and Fleetwood have only commenced to make salt within the last ten years.

Much more might be said about the salt manufacture did time permit, but it would not be right to conclude without referring to the results following the pumping of brine.

As before mentioned, brine is formed in the salt districts by the ordinary spring or well water coming into contact with the beds of salt. The moment the water reaches the salt it proceeds to dissolve it, and continues to do so until it has taken up sufficient to form a liquid containing 26 per cent. of salt. As fast as this liquid is pumped up, fresh water takes its place, and so the process of solution is continuous. The result is that the surface of the salt is eaten away in deep furrows, or miniature valleys, and the earths lying above follow the contour of the water-worn salt, making similar valleys and subsiding areas on the surface of the land. Where these sinking areas are in towns much destruction is wrought among the buildings, sewers, gas and water pipes, streets, roads and other property. In the neighborhood of brooks or rivers the subsiding areas soon become pools of water, and finally large lakes, continually increasing. In districts such as Northwich, where there are numerous worked out salt mines, the subsidence is much more serious, and enormous mischief is done. The salt districts of Cheshire are extremely interesting, showing the action of water on beds of salt on a gigantic scale, and demonstrating how changes of the earth's surface can be made by a very simple means. The question of subsidence, so interesting in itself, is too extensive to be dealt further with at the end of a paper already too long, I am afraid.

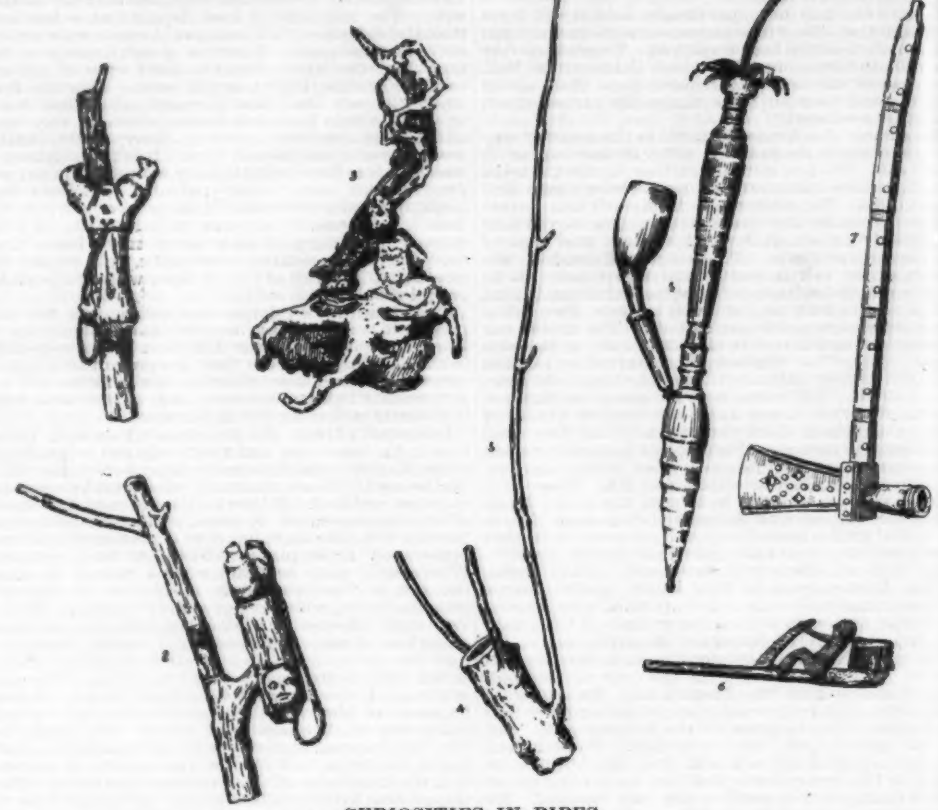
A GOSSIP ON TOBACCO.

WRITTEN UNDER THE INFLUENCE OF THE WEED.

AMONG plants of economic value none has been more generally abused than tobacco, and yet with all the blasts and counterblasts that have been written since the introduction of the habit of smoking into Europe, the soothing weed has defied them all; and, perhaps on the principle that "good wine needs no bush," the sturdy old friend of man, both in his solitary hours and convivial moments, not only maintains in this nineteenth century its reputation and veneration, but has increased it in a marvelous degree. This could be readily shown by statistics, but as statistics are for the most part dry facts, quite unsuitable for Christmas time, we will ignore them for the nonce and ask our readers to take for granted what we have said in this respect.

To use a common expression, which in this case is absolutely correct, "volumes have been written" on tobacco, and thousands of volumes, probably, under its soothing influence, to say nothing of the other thousands that are read and enjoyed with the accompaniment of the "pipe of peace." With all this before us, there would seem to be nothing new to say about tobacco, which, indeed, is the case, and on this account we have ventured to take the subject up at a season when a pipe or cigar, or tobacco in some form, is included among the luxuries which constitute the "good cheer" of Christmas; for though tobacco from the earliest period of its introduction among us has been from time to time severely condemned, the old writers who favored its use were much more enthusiastic in its praise than have been the writers of more modern days. It is both curious and amusing to note the opinions of its champions and its detractors ever since the smoking of tobacco became a fait accompli in this country. We may, however, dismiss this part of the question with a quotation from a popular and learned writer on the subject, who says: "Three hundred years ago a few American savages only consumed tobacco, and now it is consumed by all mankind, being the only commodity common to the consumption of all races and all social conditions. Are our lives shorter, our morals worse, or our intellects weaker that for the better part of three centuries the 'poisonous drug,' according to this hypothesis, has been circulating through the veins of ourselves and our forefathers?" Regarding the early history of tobacco the same writer says, "It was in the first week of November, 1492, that Europeans first noticed the Indian custom of tobacco smoking. The two sailors sent by Columbus to explore Cuba returned to the ships of their great commander, and told this among other things new and strange. They found the natives carried with them a lighted fire brand and puffed smoke from their mouths and noses; this their European notions led them to conclude was some mode of perfuming themselves. A more intimate acquaintance with the natives taught them that it was certain leaves of a herb rolled up in the dried leaves of the maize or Indian corn that they thus burned, and inhaled the smoke. It was a novelty to the Spaniards, but it was an ancient and familiar custom with the natives. The aborigines of Central America rolled up the tobacco leaf and dreamed away their lives in smoky reveries ages before Columbus was born or the colonists of Sir Walter Raleigh brought it within the precincts of the Elizabethan court."

In a translation of the travels in America of Giralamo Benzoni, from 1541 to 1556, the experience of the writer among the native tobacco smokers is given in a very quaint manner, as the following extract will show: "When these leaves are in season they pick them, tie them up in bundles, and suspend them near the fireplace till they are very dry, and when they wish to use them they take a leaf of their grain (maize) and putting one of the others into it, they roll them round tight together; then they set fire to one end and putting the other end into the mouth, they draw their breath up through it, wherefore the smoke goes into the mouth, the throat, the head, and they retain it as long as they can, for they find a pleasure in it; and so much do they fill themselves with this cruel smoke that they lose their reason. And there are some who take so much of it that they fall down as if they were dead, and remain the greater part of the day or night stupefied. Some men are found who are content with imbibing only enough of the smoke to make them giddy, and no more. See what a wicked and pestiferous poison from the devil this must be. It has happened to me several times that, going through the provinces of Guatemala and Nicaragua, I have entered the house of an Indian who had taken this herb, which in the Mexican language is called tobacco, and immediately perceiving the sharp, fetid smell of this truly diabolical and stinking smoke, I was obliged to go away in haste and seek some other place." Benzoni's view of tobacco, as here related, was not, however, participated in by all the early travelers, for a member of Sir Walter Raleigh's expedition in the discovery of Virginia at the end of the sixteenth century, after describing the uses and effects of tobacco among the people, says: "We ourselves during the time we were there used to suck it after their manner, as also since our return, and have found many rare and wonderful experiments of the vertues thereof, of which the relation would require a volume by itselfe. The use of it by so manie of late, men and women of great calling as else, and some learned phisitions also, is sufficient witnes."



CURIOSITIES IN PIPES.

1, complex pipe made of wood from Java, front view; 2, side view; 3, pipe made of laurel root, found on the battlefield at Chancellorsville, U. S. America; 4, pipe made of root of white ash from Canada; 5, pipe made of black horn from Java; 6, slate pipe from Vancouver; 7, modern American wooden pipe, made in the form of a tomahawk.

To Sir Walter Raleigh is usually accorded the introduction of smoking into England, but Fairholt, while giving him the credit of making the habit fashionable, and giving it "a good standing in society," attributes its actual introduction to Mr. Ralph Lane, who was sent out by Raleigh as governor of Virginia, returning to England in 1586, and in proof of this, says: "The historian of the voyage, Mr. Thomas Harriot, and the learned Camden, who both lived at the period, unhesitatingly affirm that Lane has the honor of being the original English smoker."

The dislike of James I. to tobacco is such a well known matter of history that we need only refer to the monarch here as being the originator of a heavy duty which was at that time imposed upon it, and which has continued with more or less change to the present time. From an original twopence per pound duty, James at once raised the impost to six and tenpence, which had the effect of almost suppressing its importation, and the plant began to be cultivated on English soil, until another act of the King made it unlawful as a home industry. Notwithstanding all this, the use of tobacco continued to increase till it has now become one of the most important articles of import, and one of the greatest sources of revenue, the imports last year amounting to 84,218,342 lb., of the value of £3,566,061. The tobacco plant is capable of cultivation in this country as has been more than once proved, the latest experiments in this direction being those carried on in 1886 by Lord Walsingham, Mr. Faunce de Laune, and Messrs. James Carter & Co., the results of which were embodied in a small book entitled "English Tobacco Culture."

Though the bulk of the tobacco of commerce is furnished by Nicotiana tabacum, the allied species N. rustica produces some portion of it. The true tobacco is a native probably of some part of South or Central America, but the precise country of its origin cannot now be determined. Martius considers it introduced in Brazil, and it is nowhere known in a truly wild

ROLLS OF NATIVE TOBACCO FROM THE RIVER NIGER.

(The long one measures 2 feet 6 inches high by 4 inches in diameter. The circular one is 18 inches across.)

state, though its cultivation has extended very widely during the present century. The genus Nicotiana derives its name from Jean Nicot, French ambassador at Lisbon, who, in 1560, brought the plant thence into France.

It is not our intention to chronicle the methods of cultivation and preparation of tobacco for market. The cutting of the plants, fermentation and drying, are facts so well known that we can afford to pass over them on this occasion, and it will suffice to say that each country of production has its own method of packing, either in hogsheads, boxes, bales, or serons. The bulk, however, comes in hogsheads, which are regulated by standard to four feet six inches in height, and will hold one thousand pounds of tobacco, the legal requirement being nine hundred and fifty pounds The small bunches of tobacco leaves which are tied together by thin stalks, and are known as "hands," are placed in layers, each layer having the points of its leaves in the same direction, but this direction being alternated in successive layers. When about a quarter full the contents of the hogshead is subjected to powerful pressure, which reduces it to about one-half its original bulk, and this process is repeated till the hogshead is full. So tightly is the tobacco compressed that it is stated that instances have occurred where hogsheads of tobacco have been washed ashore from wrecked cargoes in which, though the outer layers have been wet and spoiled, the central mass has remained quite good. The tobacco ware house in the London docks has been known to contain at one time as many as 40,000 hogsheads. When stored in this warehouse the tobacco is described as being in bond, the duty being paid as it is withdrawn for sale. It sometimes happens that the tobacco becomes injured in course of transit by the access of sea water. When this is the case the damaged portion is chopped away with long, sharp knives, and the duty is imposed only on the sound tobacco. All tobacco upon which duty is not paid is consumed in a kiln at the docks, which is popularly known as the "Queen's Tobacco Pipe."

When the tobacco is opened at the manufacturer's it is, of course, found very tightly compressed, and the layers are loosened by levers. Water is then sprinkled over them, which causes the leaves to swell, and they are then more easily separated. The next processes

FANCY INDIAN CIGARS.

(One has three ends to a single mouthpiece, so that the three ends can be lighted at the same time.)

are those of stripping out the inside of the leaf, or cutting into shreds in a variety of ways, to produce the numerous kinds of tobacco, each of which has its own admirers. The different native tribes in various parts of the world have also their own forms of preparation, two of which from Central Africa are illustrated.

We have briefly shown the importance of the tobacco plant as a commercial article in its raw and one of its manufactured conditions. For the sake of brevity we have not even alluded to the cigar manufacture and the preparation of snuff, for the former of which large quantities of the leaf are used, and for the latter—though snuff taking has almost at the present day died out in this country—still considerable quantities of the midrifs, which are stripped from the leaves for the manufacture of cigars and some smoking tobaccos, are ground into the well-known fine powder which our grandfathers and great grandfathers so highly prized under the names of Scotch, Irish high-dried, and Welsh snuffs, all of which had a high reputation for their purity, many of the English snuffs being scented and more or less artificially colored. It will probably be remembered by many readers of this paper that the regular snuff takers of thirty or forty years ago, though unable to tolerate perfumes in general, and who were very particular as to the quality of their snuff, always kept a Tonquin bean (Dipteryx odorata) in their snuff box, which retained its perfume for a very long time, and imparted its fragrance of newly-mown hay to the contents of the box. The demand for Tonquin beans at the present time is not so much among snuff takers as in the preparation of sachets and handkerchief perfumes.

Besides these immediate preparations of tobacco itself, the "weed" gives rise to many branch manufactures, as for instance, in the great variety of pipes, pouches, match boxes, and other paraphernalia of the smoker.

In all ages and in all countries fancy has run riot over designs in pipes. So much so, indeed, that the collecting of tobacco pipes has been made a hobby by some, with the result of bringing together some of the most curious and fantastic, as well as some artistic forms. A few illustrations are given, selected from several contained in the Kew Museum. Even in our own country the materials used and the shapes and styles are ever changing. Clay and meerschaum, which at one time were the dominant materials in pipe making, having long since given place to woods of different kinds, the principal of which is the so-called "brier root," which, though introduced many years ago, is still by far the most generally used and appreciated.

At first it was supposed by many that this was actually the root of the common brier, but a slight knowledge of the habits of the genus Rosa soon put the probability of this notion out of court; first, on account of the large size of the roots or wens from which the pipes were cut, and, secondly, on account of the large quantity of the roots required to meet the demand for this particular kind of pipe, which far exceeded that which could be met by any true brier. Inquiry, however, proved that brier root pipes were made from the knots or root portions of the tree heath (Erica arborea), the French name of which is Bruyere, and which by a trade corruption became brier. The roots are a large article of export from Leghorn, and are boiled in mass for a considerable time, and then dried carefully to season them and to prevent them from cracking when made into pipes by the heat of the burning tobacco. Another wood largely used at the present time is the Australian myall or violet wood (Accacia homalophylla), a beautiful dark colored wood which retains its fragrance for a very long time. More recently the English pipe market has been invaded with the queer looking articles from America made from maize or Indian corn cobs, namely, the central portion of the cob after the seeds or grains have been stripped off.

These pipes have one drawback, and that is, that when new they are covered with a coat of varnish, which, as the bowl becomes heated, not only has an objectionable smell, but the taste is also drawn into the mouth. This, however, soon passes off, and the pipes are then very sweet, and being to a certain extent absorbent, the oil of the tobacco is in some measure prevented from entering the mouth.

Space will not allow us to dwell too long on pipes and the other etceteras of a smoker's furniture, which might be extended to any length; so we will conclude with a note referring to the all-powerful weed. Here, for instance, is what our old friend Punch once said about tobacco, under the head of "A Sensible Wife."

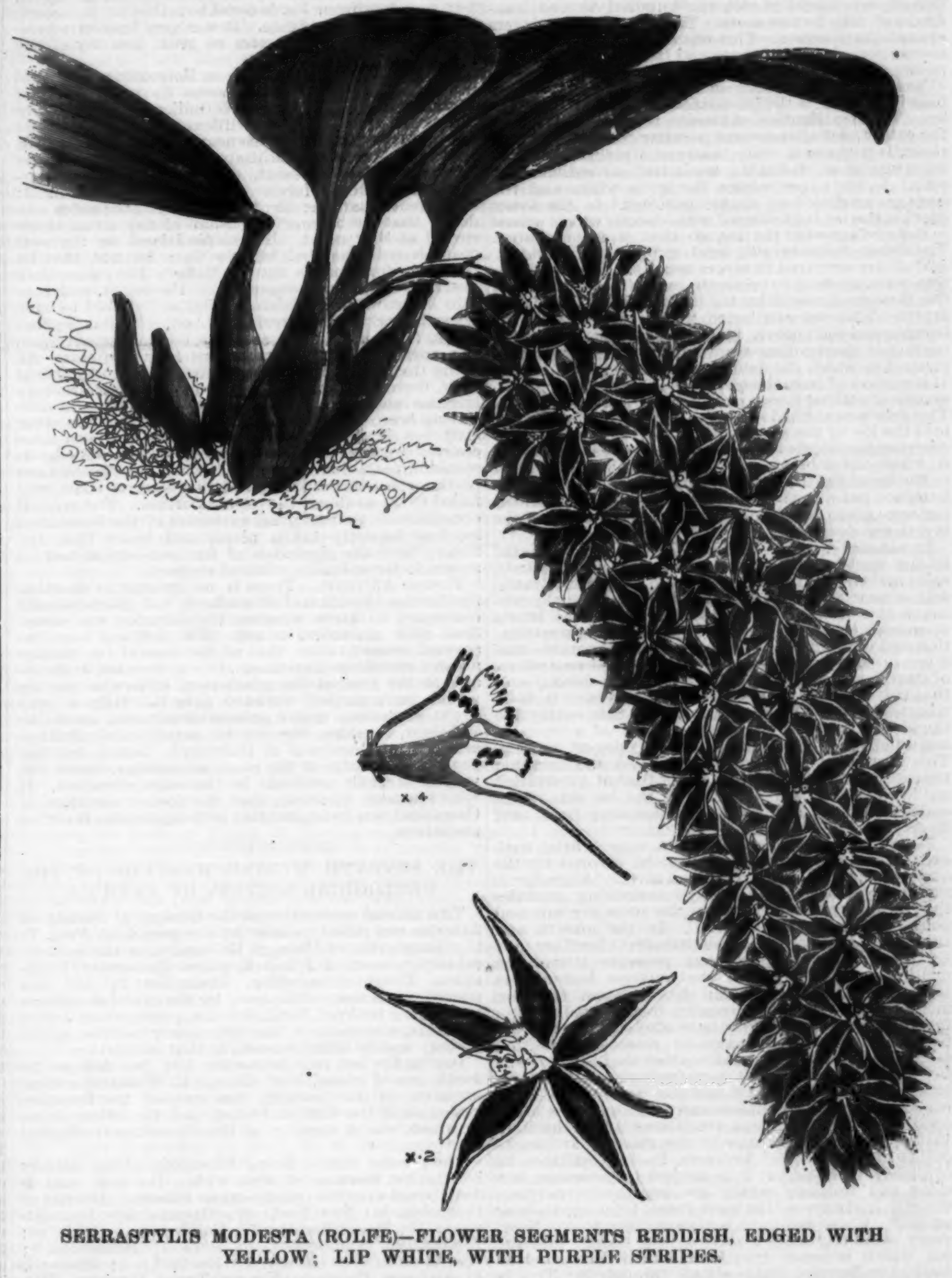
Mrs. Smith: "Why do I allow my husband to smoke in the house? Bless me, Mrs. Brown, I would not stop him for the world! Do you know, that when he is angry with me—when we have been having a few words together, as I suppose the best of husbands and wives occasionally have—he rushes to his cigar, and leaves me for a good hour all to myself. It seems to relieve him, and saves me an infinity of blowing up. After he has smoked it, I can assure you the poor creature is quite mild, and sometimes he will actually come up and beg my pardon. The fuming that I should have got is bestowed elsewhere. I look upon a cigar as the very best friend a woman has, and I'm positive, too, that it's the saving of an immensity of swearing. After all a volley of smoke isn't half so offensive as a volley of oaths. Good gracious me, only to think what beasts some men would be without their filthy tobacco There would be no going near them, I declare. When all is said and done, my dear, smoke, take my word for it, is a very fine thing. It cures many a bad temper, and preserves many a sweet one."—The Gardeners' Magazine.

SERRASTYLIS MODESTA.

ROLFE, NEW GENUS AND SPECIES.

THAT this singular orchid should have escaped detection by the many plant collectors who have passed over the Cauca seems a singular circumstance, and the fact itself should give hope to the amateurs of novelties who are content with such simple beauty and curious structure. At the end of 1893, some half-dozen plants of it were discovered by Mr. F. C. Lehmann, and in due course one which fell into the hands of Sir Trevor Lawrence flowered, and was found to be of a new genus entirely. It was named Serrastylis modesta by Mr. Rolfe, and published in the Kew Bulletin of May, 1894.

At the meeting of the Orchid Committee of the Royal Horticultural Society on Tuesday, November 27, 1894, another specimen was exhibited by Major Joicey, Sunningdale Park, Sunningdale (gr., Mr. F. J. Thorne), when it was awarded a botanical certificate, and supplied the material for our illustration. The sepals and petals are reddish, edged with yellow; the lip white, with a few purple streaks. A curious feature in the flower is the arrangement of the two large wing-like auricles on the column, the side lobes of the lip being similarly formed, and curiously arranging with them in color and shape, although on separate organ. The plant is said to stand near Brassia. In habit it resembles a small Oncidium sarcodes, and it is said to thrive well in the Cattleya house.—The Gardeners' Chronicle.



SERRASTYLIS MODESTA (ROLFE)—FLOWER SEGMENTS REDDISH, EDGED WITH YELLOW; LIP WHITE, WITH PURPLE STRIPES.

RECENT GLACIAL STUDIES IN GREENLAND.

Presidential address before the Geological Society of America, by T. C. CHAMBERLIN, LL.D. [Abstract.]

THE purpose of the studies was to find light upon some of the obscure problems of our own former glaciation. The studies consisted of: 1. A cursory scrutiny of the coast between Cape Desolation and Inglefield Gulf (a stretch of above a thousand miles), to catch the effects of former glaciation. 2. A brief inspection of three local glaciers on Disco Island near the Arctic circle, for comparison. 3. A study of the inland ice, local ice caps and fourteen derivative glaciers about Inglefield Gulf, between 77° and 78° north latitude. An effort was made to eliminate the differences due to topography and to latitude. The geological formations of Greenland are, in the main, unfavorable to glacial studies, but Inglefield Gulf probably furnishes the best conditions to be found in that country.

The feature that first impresses the observer, on reaching the glaciers of the far north, is the verticality of their walls. Southern glaciers terminate in curving slopes, and those of Disco and middle Greenland have the same habit, but the glaciers of the far north rise like an escarpment of rock one hundred to one hundred and fifty feet or more. The edges of the layers are cut sharp across. This was attributed to the low inclination of the sun's rays and their impact from all points of the compass in succession.

Next to the verticality of the edges the most impressive feature is the pronounced stratification of the ice. The stratification of glaciers is not at all new, but the extent, definiteness and peculiar characteristics of these, is perhaps in some measure a revelation. The ice is almost as distinctly laminated as sedimentary rock. In the upper portion the ice is white and the beds are produced by simple partings. In the lower portion the ice is discolored with debris, which occurs in definite layers in the ice, so that it is laminated. The debris embraces silt, sand, rubble and bowlders, and all are arranged in layers usually. The stratification was supposed to originate in the snow falls, but this does not account for the introduction of the debris layers. This was attributed to the shearing of the layers upon each other. Instances were cited and photographic illustrations shown exhibiting the precise method in which the debris is introduced into the ice. It is rubbed off from the crest of embossments or prominences of rock or gravel over which the glacier passes. The debris so rubbed off is either carried directly out into the ice by the shearing of one layer over another, carrying the debris between them, or else the layer into which the debris is introduced doubles upon itself in the lee of the prominence and becomes at length flattened out into the layer. Other evidences of shearing were given, and the faulting and contortion of the layers was described.

In summary, it appears that stratification originated in the nucleus of deposition, emphasized by winds, rains and surface melting; that the extended stratification may have been intensified by the ordinary processes of consolidation; that shearing of the strata upon each other still further emphasized the stratification and developed new horizons under favorable conditions; that basal inequalities introduced new planes of stratification, accompanied by earthy debris, and that this process extended itself so far as even to form minute laminæ. There is involved in this conception the idea of an ice layer acting as a unit of movement, and this idea is important in the physics of glaciers. This view involves the idea of rigidity of the ice rather than viscosity. The picture is not that of gravitation pulling a thick, stiff liquid down the lee side of an embossment, but of a rigid body thrusting itself over its crest.

As to the cause of glacial motion, only a brief indication of the views that seemed to be favored by the observations of the summer was given. A glacier is essentially made up of large, interlocking granules that have been developed from the snow crystals and pellets of the original snowfall. In the growth and the changes of these granules the secret of motion may lie. Thompson assumed that pressure lowers the melting point of ice, and the converse is doubtless true. Faraday and Tyndall have shown that ice melted under pressure promptly freezes again when freed from pressure. They have also shown that the presence of frozen surfaces in close juxtaposition facilitates freezing. Tyndall teaches that isolated particles or points of ice melt more freely than others from lack of support. Here are agencies which favor melting under certain conditions and freezing under other conditions, and all these conditions affect the individual granule in the mass of the glacier. It has its points of contact and pressure, its free surfaces, its capilliary interspaces; it is subject to pressures, torsions and tensions which are constantly varying. Gravity is always acting upon these, bringing to bear pressure, whose resultant is always down slope. Now, every warm day sends a wave of heat energy into the ice, which becomes transformed into the potential heat of water and passes down through it. This is competent to aid melting where the conditions favor it and to aid freezing where the conditions favor that. Here, then, are varying susceptibilities to melting and freezing connected with every granule. Here is also an agency capable of acting upon the susceptibilities, and there is a gravity ever present, bringing to bear pressure and impelling toward motion down the slope. In these agencies the explanation of glacier motion was sought.

The debris of the glacier is found chiefly in the basal fifty or seventy-five feet, and under the ice. The debris under the ice is sometimes moved by the ice and sometimes overridden by it. At the end of the glacier it is heaped up in moraines and much ice is often incorporated, which on melting gives many of the irregularities of the moraine. The glaciers drop their material in front and so sometimes build up their own pathway before them, thus that it is easy to understand how they may advance over sandy soils without abrading or disrupting them.

No eskers and kames were seen in process of formation, except miniature types. None could have been formed on the surface, because, with trivial exceptions, there is no material there of which to form them. The bottom drainage is chiefly accomplished by streams along the sides of the glacial lobes. The amount of melting is not sufficient to give large streams, and this is probably the reason for the absence of the eskers and kames. The chief bearing of the observations is in showing that the debris of the glacier is confined to its base. It does not rise higher than eskers rise; hence they cannot be supposed to be superglacial. They must be formed in tunnels beneath the ice, or in channels at its edge.

No drumlins were seen in process of formation. The observations, however, have some bearing upon their formation. The limiting of the debris to the basal layers limits the formation of drumlins to the bottom of glaciers. The weakness of the ice in comparison with its own debris gives ground for believing that drumlins could be formed under the moving ice. Drumloidal curves were seen in connection with low embossments of rock under the glacier, and the drumloidal curve is believed to suggest the process of accumulation, the debris gathering under the shearing plane represented by the drumloidal curve.

Lieutenant Peary having commenced observations on the movements of glaciers, the author did not attempt this. The physical evidences make it clear that the average rate of movement was very slow.

The amount of drift on the territory once occupied, but now free from ice, is notable rather for its scantiness than its abundance. It was very limited whereever studied, and indicates no great activity of the ice beyond its present limits.

Are the Glaciers Advancing or Retreating?—Several show evidences of retreat; some show evidences of slight advances, while others indicate that they are practically stationary. A driftless area was discovered on the edge of the inland ice near Bowdoin Bay, which shows that the ice has at that point never been further advanced than at present. This has a very important bearing on the former extension of glaciation. It is evident that the driftless area is conclusive evidence that no former extension of any moment occurred at that point. Dalrymple Island, on the west coast, is not glaciated, but the Cary Islands, that lie thirty or forty miles out in Baffin's Bay, were once overridden by a movement from the north, and contain limestone and sandstone erratics believed to have been brought from Grinnell Land, or that region. These facts indicate a considerable movement from the north, but not a movement from the east. All along the coast, from southern Greenland to Inglefield Gulf, there are stretches of mountains that are very angular and irregular and show no evidences of ever having been overridden by the ice. There are other stretches of the coast that seem to have been once covered by the ice, as their contours are subdued. It would appear, therefore, that the ice once pushed out to the coast line a portion of the western coast, and failed to do so along the other portion. The general conclusion is that no great extension of the Greenland ice has formerly taken place, and hence that the theory that the glaciation of our own region had its source in Greenland is without support.

Former Altitudes.—There is no ground to question the former elevation of Greenland, but glacialists are concerned to know whether the elevation was coincident with glaciation or not. The driftless area discovered seems to show that at the time of the former greater elevation climatic conditions were not as favorable as the present for glaciation, otherwise the ice would have pushed forward over it. Only a very slight elevation, under present conditions, would be sufficient to cause the ice to override this driftless area. The raggedness of Dalrymple Island, and the general angularity of the coast mountains, throw the weight of their evidence in the same direction. It would appear, therefore, that the former elevation of Greenland was not coincident with conditions favoring glaciation.

THE SEVENTH WINTER MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA.

THE annual convention of the Geological Society of America was called to order by the president, Prof. T. C. Chamberlin, of Chicago University, in the geological lecture room of Johns Hopkins University, Baltimore, Thursday morning, December 27, and was started on its successful career by the graceful address of welcome by Prof. D. C. Gilman, president of Johns Hopkins, who spoke of the prominent position given geology and its allied sciences in that institution.

During the last year the society lost two fellows by death, one of whom, Prof. George H. Williams, a vice-president of the society, was one of the foremost geologists in the United States, and the other, Amos Bowman, was a member of the Canadian Geological Survey.

The present active, living fellowship of the society is 229, a net increase of nine within the year, and is distributed over the continent as follows: District of Columbia, 34; New York, 27; Canada, 20; Pennsylvania, 17; Massachusetts, 17; California, 12; Ohio, 12; Illinois, 10; Connecticut, 7; Iowa, 7; Minnesota, 6; Michigan, 5; New Jersey, 5; Kentucky, 4; Missouri, 4; Alabama, Colorado, Kansas, Texas, Virginia, Wisconsin, 3 each; Maryland, South Dakota, Vermont, West Virginia, 2 each; Arizona, Georgia, Idaho, Indiana, Maine, Mississippi, North Carolina, New Hampshire, Rhode Island, Tennessee, 1 each, and 1 each in Brazil, Burma and Mexico.

The influence of the society has been marked in the direction of more sympathetic co-operation and harmonious working among the geologists of the continent, due partly, no doubt, to the personal contact and acquaintance fostered by the semi-annual gatherings of the fellows. The activity of the organization is attested by the five handsome volumes of the Bulletin, comprising more than 2,900 pages of text, with 77 plates, which have been issued in the past six years.

By the death of Prof. Williams, the society loses one of its most able, active and enthusiastic members, a man who had "grown out of local into national work and importance." A fitting memorial was read by Prof. W. B. Clark, his colleague in Johns Hopkins University, and several fellows of the society took the opportunity publicly to express their high opinion of Prof. Williams as a geologist, as a teacher and as a man. A biographical notice of Prof. Williams has already appeared in the columns of the SCIENTIFIC AMERICAN.

Dr. H. M. Ami, of Ottawa, presented a memorial of the other deceased member, Mr. Amos Bowman, who was largely instrumental in organizing the first California State Geological Survey, and later in life removed to Canada.

The scientific part of the programme was introduced by Prof. N. S. Shaler, of Harvard University, who read a paper on certain features in the jointing and veining of the Lower Silurian limestones near Cumberland Gap, Tenn. These features, which are several series of parallel lines or narrow grooves, have been referred by some authors to ancient glaciation. Microscopical investigation shows, however, that the grooves are innumerable gash veins of calcite in the dolomite which have been eroded at the surface. No distorting strain seems to be proved, and the fissures must be due to contraction and jointing in peculiar fashion.

Mr. C. D. Walcott, director of the United States Geological Survey, then gave an exposition of the Appalachian type of folding of rock strata shown in the White Mountain range of Inyo County, Cal. This range is the next one east of the Sierra Nevada and rises to nearly the same height, more than 14,000 feet. A typical closed and overthrust synclinal fold, with strata diverging on each side of it like the sticks of a fan, is plainly shown in the walls of the Silver Canon. The trough of the fold is here 3,000 feet deep, and is overturned toward the east, instead of toward the west, as is the case in the Appalachian system. The sharpness and depth of the syncline diminish toward the south. The range lies in the midst of the great arch indicated by the Wahsatch Mountains on the east and the Sierra Nevada on the west. No Archæan rocks are now known to be exposed in the region.

In another paper Mr. Walcott gave a brief account of the discovery of Lower Cambrian rocks and fauna in the same mountain range.

"New Structural Features in the Appalachians" was the topic discussed by Mr. Arthur Keith, of the United States Geological Survey. The regularities in structure were shown long ago by Professors Hall, Safford and others, but the smaller irregularities are of great importance in tracing out the history of the region, and they have been studied only within the last few years. His investigations in this field have led the author to adopt a theory that the compressive strain which deformed the strata began in the crystalline gneisses and granites. This thrust the crystallines against the sedimentary strata, and by differential motion along the shear zones produced buttresses around which the chief changes of structure were grouped.

The discussion which followed the reading showed that not all of Mr. Keith's colleagues have accepted his views, as they hold to the old idea that the crystalline axis was the stable portion of the region.

Prof. H. P. Cushing, of Cleveland, then read a paper on the faults of Chazy township, Clinton County, N. Y., in which he gave the results of some detailed mapping in a region which is noted in the history of palæontology. That the Lake Champlain region is, structurally, one of faulting without folding is well known. The structure is well exhibited in Chazy township, and its consideration is of importance, because of its bearing on the structure of the Adirondack region, in which, on account of the lithological similarity of the rocks, the determination of their precise relations is a matter of very great difficulty. The great number of the faults and the consequent small size of the various fault blocks are striking facts. The main series of faults trends about northeast, and brings Potsdam and Chazy rocks into contact. This series has a throw of about 2,000 feet.

In a paper entitled "The Formation of Lake Basins by Wind," Mr. G. K. Gilbert, of the United States Geological Survey, described certain phenomena which had come under his observation in the arid regions of the Southwest. The region immediately under consideration is occupied by Cretaceous shales, and the basins described usually lie on the divides between drainage systems, and are saucer-like depressions in the hillsides, with a slight elevation on the side farthest from the direction of the prevailing wind, which is westerly. When the basin is on the eastward slope of the divide and the elevation, consequently, is below it, water collects in it, and a lake is formed which is more or less persistent. Two of the conditions favorable to the formation of basins in this way are an arid climate and a soil unprotected by vegetation.

In another paper Mr. Gilbert gave the results of an attempt to measure the extent of Cretaceous time by a study of the stratigraphic succession in the same region, the drainage basin of the Arkansas River. Here there is a great thickness, about 3,900 feet, of limestone and shale, which is divided into couplets, consisting of a foot to a foot and a half of limestone and an inch or so of shale. On account of their regularity these alternations are hardly to be accounted for by oscillations of level. The suggestion is made that the alternations are due to climatic cycles. Such an amount of sediment as 18 inches could scarcely be deposited in as short a time as one year at the distance from the Cretaceous shore line at which these strata were laid down. The lunar cycle does not seem to effect great climatic changes. The cycle of the precession of the equinoxes, however, produces great climatic changes, and changes of the position of the earth's poles. It requires about 21,000 years to complete.

Mr. Gilbert would assign about 4 feet of these strata to each such cycle, which gives about 21,000,000 years as the measure of this portion of Cretaceous time. This result is rather staggering when one considers what a small part of the geological scale is occupied by these strata.

The Tepee Buttes are certain conical hills which dot a portion of the Arkansas basin like enormous Indian tepees or tents. They were made the subject of special study last summer by Messrs. Gilbert and F. P. Gulliver, and the latter described them to the society with the aid of numerous lantern slides. The cones consist of limestone largely made up of the shells of one species of mollusk, and were originally surrounded by great beds of shale which have been mostly removed by erosion.

In the course of some remarks on the geology of Arizona and Sonora, Mr. W. J. McGee, formerly of the United States Geological Survey, but now of the

Bureau of American Ethnology, said that buttes near the Gulf of California have very little talus, and show that not very long ago, geologically speaking, the gulf had stood several hundred feet higher than now. The surface rocks in Arizona are mainly of volcanic origin, while in the Mex.can portion of the region, Mesozoic limestones prevail. The rivers, all of which have definite heads in the mountains, but are absorbed by air and earth before they can reach the ocean, do not follow the great valleys, but they traverse them and the mountain ranges, on account of the general dip of the whole plain to the southwest.

Dr. J. W. Spencer continued the series of papers on Cuba begun last summer at the Brooklyn meeting of the society, by describing the geological evolution of the island. He first spoke of the physical geography of Cuba, and of the adjacent submerged banks and fjords. Exclusive of a few areas locally older, the apparent foundation of the island is composed of volcanic rocks of Cretaceous or slightly earlier date. These are succeeded by fossiliferous Cretaceous sands, etc., and limestone greatly disturbed. The Eocene and Miocene deposits form a physical unit, and are composed mostly of limestones having a thickness of from 1,900 to 2,100 feet. The Pliocene period was mostly one of high elevation accompanied by very great erosion. At the close of this period the Matanzas subsidence depressed the island so as to leave only a few small islets and to permit the accumulation of about 150 feet of limestones. Then followed the great Pleistocene elevation, with the excavation of great valleys, the lower portions of which are now fjords, reaching in one case at least to a depth of 7,000 feet before joining the sea bottom beyond. The elevation was followed by the Zafata subsidence, which reduced the island to smaller proportions than those of to-day, and permitted the accumulation of loams and gravels like the Columbia formation of the continent. Subsequent minor oscillations are indicated by terraces and recent small canons now submerged.

Some of the results of two of the several Arctic expeditions of last summer were given in papers by Profs. T. C. Chamberlin and G. F. Wright, the former of whom was geologist to the Peary relief expedition, and the latter was with the ill-fated party led by Prof. Scott. Prof. Chamberlin's elaborate report was presented as the presidential address to the society, and was profusely illustrated by stereopticon views. It contained so much of interest and importance that a full abstract will be found elsewhere in the SCIENTIFIC AMERICAN.

Prof. Wright stated the direction of the glacial scratches in Newfoundland, and the evidences of a preglacial elevation of the island. The well rounded and flowing outlines of the coast range of mountains in Labrador are in marked contrast with the jagged character of the coast of southern Greenland, due to numerous needle-like peaks rising from 2,000 to 4,000 feet, which evidently have never been completely covered by the ice cap, though glacial striæ have been found on the mountains up to 1,500 feet above the sea. A description was also given of the projection of the inland ice, which comes down to the coast near Sukkertoppen, in latitude 65°50′, and of the phenomena which indicate the former extension of the Greenland ice far beyond its present limits. The absence of till or other glacial deposits in any large amount is very noticeable both on Labrador and Greenland. In discussing this paper Mr. C. D. Walcott stated that his observations had led him to believe that the main work of base leveling on Newfoundland and Labrador was done in prepaleozoic time, and that not much had been accomplished by glaciation.

In a communication on high-level gravels in northern New England, Prof. C. H. Hitchcock stated that recent observations had proved the existence of level-topped terraces or beaches in the southern part of the Lake Memphremagog drainage basin. These prove the existence of a glacial lake in that region.

Prof. H. F. Reid, of Baltimore, has been making a study of the variations of glaciers, especially those of Switzerland, and he presented the results of his investigations in a brief and interestng paper. Between the years 1735 and 1880 periods of maximum cold and dampness of the Swiss climate have recurred about once in 35 years, and in general there seems to have been a corresponding advance of the glaciers. It is very difficult to correlate the data, at the same time different glaciers in the same region present different phases of advance or retreat. The velocity of a glacier depends upon snowfall, as well as upon the inclination, configuration and nature of its bed. The thicker the ice at the point, the slower the retreat, though the amount of ice melted be the same. Contrary to the general impression, glaciers are never in a state of equilibrium, but are always advancing or retreating, though the movements are very slow.

Mr. Warren Upham, of Somerville, Mass., presented a paper on the discrimination of the accumulation of ice sheets by snow on their entire area from an advance or invasion by the front of the ice, extending the glacier thus into new territory. He showed that the former condition had been generally prevalent in the glaciated portions of both North America and Europe by the occurrence of comparatively small areas of ice accumulation beyond the extreme boundaries of the principal ice sheets. The condition of ice invasion is indicated on the outer part of the drift-bearing area eastward from Salamanca, N. Y., through Staten and Long Islands, Martha's Vineyard and Nantucket, where the soft strata beneath the ice were dislocated and folded.

Mr. Upham followed this paper with one on the climatic conditions shown by North American interglacial deposits. During the times both of general accumulation and growth of the ice sheets and of their final recession, fluctuations of their borders were recorded in several districts by forest trees, peat and molluscan shells, inclosed in beds underlain and overlain by till. Such beds formed while the ice accumulation was in progress inclose chiefly Arctic or boreal species; but when the ice was being melted away in the Champlain epoch, the flora and fauna, according to the remains preserved in interglacial beds, as at Toronto and Scarboro, Ont., may be wholly those of a temperate climate, such as now exists in the same region. The cold climate of the ice age appears thus to have been followed by a temperate climate close upon the waning ice border.

"Glacial Lakes in Western New York," "Lake Newberry, the Successor of Lake Warren." These were the titles of two papers by Prof. H. L. Fairchild, of Rochester, N. Y., which were introductory to more detailed study of the lacustrine history of western New York. It was shown that all the present deep valleys of the linear or "Finger" lakes were, during the retreat of the ice sheet, filled with water to the height of the drift cols south, and that they overflowed into the Susquehanna. The old channels are well shown and the deltas built by streams debouching into the glacial lakes. The glacial Seneca, named the Watkins Lake, and the glacial Cayuga, called the Ithaca Lake, were over 1,000 feet deep. Similar lakes were formed in other valleys inclined northward in which no lakes now exist. Eighteen of these local lakes were named, ranging from the Onondaga Valley on the east to the Tonawanda Valley on the west.

When the ice front receded northward the local lakes were lowered to the level of a vaster lake, which had its outlet through the Seneca Valley over into the Chemung at Elmira. By the depression of Central New York this outlet was lower than the Chicago outlet, which had been the previous one. For this newly determined lake, lying at a lower level than Lake Warren and higher than Lake Iroquois (outlet by the Mohawk), the name "Lake Newberry" was given.

In describing the glaciation of Newfoundland Prof. Chamberlin said that in general the movement of the ice seems to have been from the interior of the island toward the coast and to indicate the existence of a local glacier. There was, apparently, very little transportation of material except by the peripheral portions of the glacier.

Passing at one step from very recent formations to the most ancient rocks on the continent, the next paper was "A Further Contribution to Our Knowledge of the Laurentian," by Prof. F. D. Adams, of Montreal. After referring briefly to his previous work on certain intrusive rocks of the Laurentian area, the author gave a condensed account of the results of a study of the stratigraphical relations and petrographical character of the gneisses and associated rocks of the Grenville series in that portion of the Archæan protoxis which lies to the north of the island of Montreal. The paper was illustrated by numerous lantern slides, the most remarkable of which were some rock thin sections about three inches in diameter, made in Upsala, Sweden, and used without further preparation in the stereopticon.

Following this the lantern was used to illustrate a discussion of "The Crystalline Limestones and Associated Rocks of the Eastern Adirondacks," by Prof. J. F. Kemp, of Columbia College. The areas of these rocks especially referred to lie in Essex County, and were shown to be generally small, usually less than a square mile in extent, and to consist (a) of white, graphitic, crystalline limestone, with great numbers of inclusions of silicates, (b) of ophiolites, (c) of black garnetiferous hornblende schists, (d) of lighter gray schists and (e) in one area of closely involved granulite very much like the Saxon granulite.

The evidence of the plasticity of limestone under pressure was graphically shown in the photographs. The trap dikes that often cut the limestones were referred to and the relations with the intrusive gabbros set forth. The argument was made that the limestones are older than the gabbros and anorthosites of the Norian series, and that they are the remnants of an extended formation which was cut up by these intrusions, largely metamorphosed by them and afterward eroded.

The corresponding areas on the western side of the Adirondacks in Jefferson and adjoining counties have been made the subject of especial study recently by Prof. C. H. Smyth, Jr., of Clinton, N. Y., whose conclusions as set forth at length in the next paper may be summarized here. In this region we have a series of sedimentary rocks consisting of heavy beds of crystalline limestones and interbedded gneiss associated with igneous rocks from which it is not always possible clearly to separate them. Certain hornblendic and pyroxenic gneisses which are constantly associated with the limestones may be in part modified igneous rocks. Several varieties of undoubted igneous rocks, chiefly granite and gabbro, with minor diorite and diabase, are all younger than and intrusive in the sedimentary series and produced marked contact metamorphism therein. Many of the famous mineral localities of the State lie in these contact zones. The relative age of the intrusions is not clear except for diabase, which is the youngest of the rocks. Besides these rocks, whose origin is fairly clear, there are wide areas of gneisses whose origin and relation to the other formations are matters of doubt.

The paper presented by Prof. H. S. Williams, of Yale University, related the discovery of certain Devonian forms of mollusks in the much younger strata belonging to the upper portion of the Lower Carboniferous period occurring in the Spring Creek limestone of Arkansas. The species noted do not occur in the Devonian rocks of the Mississippi, but are found farther west, as well as in New York State. The author accounts for their presence in the Arkansas rocks by supposing that there was an incursion of Devonian forms of life from the West.

The paper entitled "The Pottsville Series Along New River, West Virginia," by David White, of the United States Geological Survey, was an important contribution to stratigraphical geology, but was too technical for reproduction here.

Prof. W. B. Clark, of Johns Hopkins University, read two papers, one on the Cretaceous deposits of the northern half of the Atlantic coastal plain and the other on the marginal development of the Miocene beds in eastern New Jersey. In the first the author stated that he had given local names as follows to the economic subdivisions of the New Jersey Cretaceous made by the late Prof. Geo. H. Cook, in ascending order:

Raritan, of Clark,	=	Plastic clay, of Cook.
Matawan	=	Clay marls.
Navesink	=	Lower marl bed.
Redbank	=	Red sand.
Rancocas	=	Middle marl bed.
Manasquan	=	Upper marl bed (lower part).

All of these, except the last cross New Jersey, Delaware and the eastern shore of Maryland, while the first two extend even to the western shore near Washington. The last has not been identified outside of New Jersey. Prof. Clark's second paper discussed the wide extent of Miocene beds in Monmouth and Ocean Counties, N. J. The gravels, sands and clays were considered, and their relations shown, together with the occurrence of glauconite in certain areas, and the article closed with a brief explanation of the connection of the strata in the northern counties with the highly fossiliferous beds in South Jersey.

"Sedimentary Geology of the Baltimore Region" was the title of a paper by N. H. Darton, of the United States Geological Survey. Baltimore is built on hills of Pleistocene age. In the general region four of the great coast plain formations are exposed. The Potomac strata are most prominent, while the Chesapeake, Lafayette and Columbia formations are represented. The author gave a brief history of the successive depositions, elevations and erosions.

Prof. R. D. Salisbury, of Chicago University, in a paper on the surface formations of southern New Jersey, gave some of the results of several seasons field work for the State geological survey. The author believes that these formations, which have often been grouped together under the names "Yellow Gravel" and "Columbia," are really divisible into four formations, the oldest of which greatly antedates the glacial period. The several beds are unconformable to each other and are believed to have been widely separated in point of time.

Mr. Waldemar Lindgren's paper on "The Characteristic Features of the California Gold Quartz Veins" brought out many interesting facts. These veins are not confined to the contact between the granite and slates, nor do they by any means characterize the contact, as Von Richthofen has said. Prof. J. D. Whitney's statement as to the parallelism of strike and dip of veins must be rejected also. The veins are true fissure veins, and the origin of the gold must be sought in rocks below those which now form the surface of the Sierra Nevada. An important chemical change in the country rock near the fissures has been in the production of carbonates.

Dr. G. P. Merrill then described and showed specimens illustrating the great decomposition in situ suffered by the crystalline rocks of the District of Columbia. And Mr. Bailey Willis, of the U. S. Geol. Survey, closed the scientific part of the convention by relating the various cycles of deposition, elevation, decomposition, erosion and redeposition that have taken place in geologic time, especially in the Appalachian Mountains. In the absence of their authors, abstracts of several other papers were read by deputies.

While a portion of the above described programme was being carried out, those especially interested in petrography obtained the permission of the society to expedite clearing away the long list of papers by withdrawing to consider topics of peculiarly petrographic interest. Under the genial chairmanship of Prof. B. K. Emerson, of Amherst College, eight papers by the following authors were disposed of: Prof. W. S. Bayley, of Waterville, Me.; Dr. Alfred C. Lane, of the Michigan Geological Survey; Mr. L. S. Griswold, of Harvard University; Dr. E. B. Mathews, of Johns Hopkins; and Prof. J. F. Kemp. Most of these contributions provoked much friendly discussion and the "family party" was considered a great success.

In all, forty-seven papers were on the programme, of which forty-four were read in whole or in abstract. The photograph committee reported the accession of more than four hundred views, and the display of nearly twelve hundred photographs was one of the features of the meeting.

The council reported that five new fellows had been elected to the society.

The library has grown to such dimensions that permanent quarters have become necessary, and an arrangement to that end has been perfected with the Case Library, of Cleveland, Ohio, and a scheme for making it useful is before the society. The officers for 1895 are: president, Prof. N. S. Shaler, of Harvard University; first vice-president, Prof. Joseph Le Conte, of the University of California; second vice-president, Prof. C. H. Hitchcock, of Dartmouth College. The secretary, treasurer and editor are the same as heretofore.

On Thursday evening the authorities of Johns Hopkins University tendered the four scientific societies in convention in Baltimore a reception in McCoy Hall. Friday noon the resident members of the societies gave the visitors a luncheon and Friday evening the Geological Society held its annual dinner, so that social matters were not wholly lost sight of in the midst of so much solid fact and abstruse reasoning. More than sixty fellows and many others attended the sessions of the Geological Society. After passing a vote of thanks to the University and Prof. Clark and Dr. Mathews, of the geological department thereof, the convention adjourned to meet again next summer with the American Association for the Advancement of Science, in San Francisco or elsewhere.

PROF. VICTOR MEYER'S NEW METHOD OF DETERMINING HIGH MELTING POINTS.

A DESCRIPTION of improved apparatus for the determination of high melting points, by his admirable new method, is contributed to the current Berichte by Prof. Victor Meyer, in conjunction with his students Messrs. Riddle and Lamb.

The simplicity of the method will doubtless cause it to take rank immediately among the standard processes for the determination of physical constants, and alongside the universally popular method of determining vapor densities, which we likewise owe to the distinguished Heidelberg professor. Naturally, however, operations at temperatures higher than those at which the hardest varieties of glass soften must perforce be conducted in apparatus constructed of platinum, just as in the cases of the determinations of vapor density at the same high temperatures. One of the main advantages of the method is that it only necessitates the use of a very small quantity of the substance whose melting point is to be determined, thus enabling it to be extended to compounds of the most extreme rarity.

The method is based upon the principle of measuring the temperature by means of a miniature air ther-

mometer constructed of platinum, the air contained in which is expelled, at the moment when the fusion of the substance under investigation occurs, by means of a soluble gas into a gas-measuring vessel filled with a liquid capable of dissolving the expelling gas. The substance whose melting point is to be determined is placed in a small and very narrow platinum tube, which is fixed to the bulb of the air thermometer during the operation, and both are immersed in a bath of a fused salt whose melting point is considerably below that of the substance under investigation. Hence, the operation of determining a high melting point by this method is perfectly analogous to that usually adopted in determining ordinary melting points lower than the temperature of boiling mercury.

The air thermometer is simplicity itself. It consists of a spherical platinum bulb of about 25 c. c. capacity, from which rise parallel to each other two relatively long capillary tubes, also of platinum. One of the tubes passes down into the interior of the sphere, almost touching the opposite inner surface, while the other only just pierces the envelope. Both are bent at right angles at their upper extremities, in opposite directions. In order to eliminate all errors due to the capillary tubes a compensator is also employed, consisting of a long capillary U tube of the same bore and bent at right angles at the extremities, so as to form an exact counterpart of the capillary portion of the air thermometer. The small tube containing the substance is firmly fixed by means of stout platinum wire so that its lower portion is in close contact with the sphere; the walls of the tube are of the same thickness as those of the sphere. The salt employed for the purposes of a bath is contained in a capacious platinum crucible, supported over a table furnace in a miniature basket of platinum gauze. One of the capillary tubes of the air thermometer is ready to be connected with an apparatus for generating pure carbon dioxide, and the other is attached to a gas measuring burette similar to the well known Schiff nitrogen apparatus, but somewhat narrower, and surrounded by the outer tube of a Liebig's condenser, through which a stream of cold water is continually passed. This arrangement enables the air to be collected and measured in the proximity of the furnace. The measuring burette is filled with a concentrated solution of caustic potash. The temperature of the water jacket is measured by a thermometer immersed in a small accessory reservoir, through which the water passes immediately after leaving the jacket. A very simple device has been adopted for determining the exact moment when fusion occurs.

Before the experiment the little test tube is heated until the substance melts; a fine platinum wire, furnished with a thickened end, is then inserted in it, and allowed to become fixed by the solidification of the substance. The fine wire is then passed over a pulley some distance overhead and the free depending end is attached to a weight; just below the weight a bell is hung.

When everything is ready for the actual operation of determining a melting point, the salt in the crucible is fused, the lower part of the air thermometer and its attached substance tube are inserted in the bath of liquid, as is likewise the compensator, connection with the measuring burette is made and the carbon dioxide apparatus is arranged to be delivering the pure gas. When the temperature of the bath at length attains that of the melting point of the substance, the portion of the latter in immediate contact with the walls of the platinum tube fuses and instantly the wire is released and the weight falls and strikes the bell. The moment the sound is heard, connection with the carbon dioxide apparatus is established, and the air contained in the thermometer is displaced and driven into the measuring burette. The compensator is similarly treated and the quantity of air which it contained deducted from that contained in the thermometer. From the resulting volume, together with the knowledge previously obtained concerning the capacity of the thermometer and compensator and the known expansion of air, the melting point is obtained by a very simple calculation.

Four groups of interesting results have already been obtained by use of the new method, indicating the dependence of the melting point upon atomic weight. They are as follows:

Salt.	Melting Point, Degrees.
Potassium chloride	800·0
Potassium bromide	722·0
Potassium iodide	684·7
Potassium iodide	684·7
Rubidium iodide	641·5
Cæsium iodide	621·0
Sodium chloride	815·4
Sodium bromide	757·7
Sodium iodide	661·4
Calcium chloride	806·4
Strontium chloride	832·0
Barium chloride	921·8

It will be observed that in the halogen salts of both sodium and potassium a diminution of melting point accompanies a rise in the atomic weight of the halogen; also that a lowering of the melting point accompanies a rise in the weight of metallic atom in the case of the iodides of the alkali metals potassium, rubidium and cæsium, while the reverse occurs with respect to the chlorides of the alkaline earthy metals calcium, strontium and barium. Whether there is rise or fall of the melting point with ascending atomic weight, however, the salt of intermediate molecular weight invariably exhibits an intermediate melting point.—A. E. Tutton, in Nature.

ORIGIN OF NITRIC ACID.

By Dr. T. L. PHIPSON, Graduate of the Faculties of Science and Medicine of the University of Brussels; Fellow of the Chemical Societies of London, Paris, Antwerp, etc.

ONE of the most striking facts in the whole range of chemistry is that the two substances, ammonia and nitric acid, so essentially opposite in character, are readily convertible one into the other.

For instance, in one of my recent experiments, liquid ammonia somewhat diluted was simply poured into a solution of permanganate of potash and the mixture allowed to remain for some days. The liquid being then filtered from the hydrated peroxide of manganese, and allowed to evaporate spontaneously in a warm room, produced crystals of nitrite and nitrate of potash. If the ammonia is in excess, the nitrite predominates; if the permanganate is in excess, the nitrate alone is obtained.

Again, if zinc or tin be dissolved in dilute nitric acid, the liquid produced yields ammonia, a fact that has long been known.

In my note "On the Nature of Nitrogen" (Chemical News, vol. lxix., p. 207), I stated incidentally that in nature nitrates are "undoubtedly the residues of organic life." I will now look a little closer into this question.

A certain quantity of nitrogen is supposed to be extracted year by year from the atmosphere by the natural process known as "nitrification." In what does this process consist? It has occupied the thoughts of many eminent chemists in all parts of the world, especially since the days of Napoleon Bonaparte. Many are the theories that have been put forth to explain it—porous bodies, catalysis, electricity, bacteria, etc.—and we may safely assert that hitherto it has remained unexplained. No one seems to have realized that this process is universal, that it occurs constantly everywhere. But it is only in certain countries where rain is scarce that the resultant nitrates are easily discovered; for instance, certain parts of India, Peru, Egypt, Arabia, China, Persia, Kentucky, Les Landes (France), etc. Where the climate is dry, the nitrates are seen to effloresce on the soil; in all other parts they are washed away by the meteoric waters as rapidly as they are produced, and find their way into the rivers.

In my opinion nitrification simply consists in the oxidation of ammonia; for in a series of experiments I made many years ago with the view of forming saltpeter artificially by passing air through various bodies, I never obtained any nitrates unless some ammonia-yielding substance was present, though, doubtless, traces might be obtained from the ammonia always present in minute quantity in the air.

Now, ammonia is not only a volcanic product, but an organic residue—a secretion that has found its way into the artificial strata of the earth ever since life appeared upon the globe.

All nitrates are due to ammonia, and ammonia is a residue of animal and vegetable life, but it is also a volcanic product, like carbonic acid.

Ammonia kills plants, but nitrates are absorbed by all, and we find them in considerable quantity in the nettle, the tobacco, the sunflower, etc. In an analysis I made of a sample of Virginia tobacco leaf (grown upon a soil without manure), which arrived at my laboratory just as it was taken from the soil, the substance, when heated in a platinum crucible, deflagrated in a very notable manner during incineration.

Nitrates are absorbed as such from the soil, and in the plant cell they are reduced, deprived of their oxygen, which is secreted into the atmosphere by the plant, and their nitrogen enters into the composition of albuminous bodies, which, on the final decay of the plant, are reduced to ammonia.

Liebig, in his well known "Principles of Agricultural Chemistry" (p. 20), says: "There is every reason to believe that in the process of vegetation nitric acid can replace ammonia as a source of nitrogen." But I must go much further than that, for I have convinced myself that ammonia is converted into nitric acid before its nitrogen can be assimilated, and that ammonia will kill or injure the plant unless this conversion can take place.

In seeking, therefore, to discover the origin of nitric acid in nature we are compelled to ask, What is the origin of ammonia?

Ammonia is found among the products of volcanic action, and the celebrated chemist Wohler set up the hypothesis that its presence in the gaseous emanations of active volcanoes is due to the action of steam upon deposits of nitride of silicium. In considering the boracic acid lagunes of Tuscany, it would have been easy, also, to have imagined it due to deposits of nitride of boron. But unfortunately for this notion deposits of such artificial products have never been met with in nature; and it is quite as possible that volcanic ammonia may be of organic origin, like that of the vast guano deposits of our own time, or like that derived from coal or petroleum, etc. Though traces of ammonia have been found in all mineral springs rising through secondary and tertiary strata, it has never been detected in the water of springs rising and flowing directly from the primitive rocks, such as granite. Nevertheless it has recently been found in the mineral apophyllite.

At the present the average amount of ammonia in our atmosphere is to that of the carbonic acid as 3 is to 100; and this amount was considered by Liebig to be sufficient to supply the whole of the nitrogen required for plant life (and consequently for animal life) all over the globe. But he does not appear to have been aware of the constant and universal production of nitric acid. He believed that all the nitrogenous principles of plants are derived directly from ammonia, and many still hold the same opinion, whereas they are evidently derived from nitric acid, which itself is derived from ammonia by the natural process of nitrification.

The substance of plants and animals produces ammonia by its natural decay, and this ammonia, by being oxidized, produces nitric acid. The latter is again absorbed by plants, transferred to animals as albumen, etc., and finally reduced to ammonia by the decay of both.

If, therefore, we follow the atom of nitrogen through organic nature, we find that nitric acid is not the first formed, since it must be derived from ammonia.

I was thus led to look upon ammonia as originally a volcanic product, like carbonic acid, and as the prime source of all nitrogen compounds.

In the primeval ages of the globe there could have been no nitric acid, nor even ammonia; but when the earth had cooled sufficiently—long before life appeared—ammonia could have existed in the volcanic products as it does at the present day. Later still, nitric acid formed from this ammonia was produced and plant life became possible. When organized beings perish and decay, their nitrogen and carbon return to nature as they originally existed, that is, as ammonia and carbonic acid.

Hence we see that atmospheric nitrogen takes no part in the process of nitrification, unless it be the comparatively small quantity which appears to be invariably converted into nitric acid during combustion, and by lightning; but this, after all, may be due to atmospheric ammonia.

These brief arguments, based upon direct chemical experiments, will, perhaps, again prove that questions of the simplest nature are beyond the powers of science the moment they touch on the theory of creation.

It has been said of the ancient Britons, that those on the coast came from Gaul, but those who lived in the interior arose from the soil. This is, indeed, the safest opinion; for if we say they all came from Gaul, it will be asked, Where did the Gauls come from, if not from some more eastern country? And so we may go round the globe, through India and the New World, till, unlike Columbus, we get back to Britain again.—Chemical News.

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